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THE LEASE OF THE WEST END ST. RY. CO., which controls all the street railway lines of Boston, to the Boston Elevated R. R. Co., has just been ratified by the directors of both corporations. According to the press dispatches the terms of the lease are as follows:

On or before Jan. 1, 1898, at least $5,000,000 in cash shall have been paid in upon the capital stock of the Boston Elevated. Until such payment the West End is to remain in possession. The lease is not to be valid until the Board of Railroad Commissioners have given their approval of it.

The elevated company is to pay all expenses of the West End of every kind, including the maintenance of the corporation; also $3,750 each six months, and 8% on the West End common and preferred stocks. The West End turns over to the elevated everything, including cash on hand and the subway contract. The lease runs for ninety-nine years. The elevated pays all West End indebtedness, except the schedule indebtedness, and all taxes and all expenses in connection with transfer or registration of West End stock.

In the case of any disagreement under the lease, or anything growing out of it, the issue shall be determined by arbitrators, each side selecting one, and they choosing a third. In case of failure to appoint an arbitrator or agree upon a third, the Railroad Commissioners or Chief Justice of the Supreme Court may appoint the same.

The West End Co. owns 284 miles of street railway track and it paid last year dividends of 8% on its preferred and 7% on its common stock. The Boston Elevated R. R. Co. is a new corporation which proposes to build elevated structures along some of the lines of travel where the amount of traffic is greatest. These elevated roads will doubtless be operated by electricity and will run into the business center through the new subway.

THE SMALL COST OF PIG IRON PRODUCTION in the most favorably situated locations and under the most economical working was well set forth in a paper by Mr. John Birkinbine, read before the summer meeting of the American Institute of Mining Engineers. We quote as follows:

This abundance of ore of excellent character but beyond the phosphorus limit for Bessemer purposes in the Lake Superior region offers the expectation of pig iron for other than Bessemer use being produced at low cost, necessitating cheap mining and transportation. The writer lately had opportunity to examine the labor accounts for three consecutive months connected with the mining of coal, coking of the same, mining of ore, transporting raw materials to the furnace, the production of pig iron and the delivery of the same on cars. The total number of days' labor at mines, ovens, furnace, and a proper proportion for railroad transportation, divided by the total tons of pig iron produced gave a quotient less than four. That is, pig iron is now being produced in the United States for less than four days' labor per ton of metal, from the time the native materials are attacked under ground to the delivery of the pig metal on cars for shipment. Such is the competition which the miners of ores must be prepared to meet, but as an offset another blast furnace plant shows that 3½ tons of pig iron were produced for each day's labor connected with the furnace. In each of the above instances every employee outside of the office force was included in the total; and while each record may be considered as exceptional at the present time, they set a standard which all engaged in the production of pig iron must expect to meet, and those who supply ore must be able to reduce their labor costs to a minimum.

CORE MAKING is one of the difficult features in foundry practice, and anything which will make the work more simple or reliable will be hailed with delight. A new compound now being placed upon the market by the Holland Linseed Oil Co., 685 Austin Ave., Chicago, Ill., seems to meet the requirements in a satisfactory manner. In its use from 30 to 60 parts of sand are taken to one of the compound, depending on the character of the core to be made. The method of manufacturing the core then proceeds as with the common flour mixture. The claims are that as air and moisture have little or no effect upon the substance, a considerable quantity can be mixed at one time and kept in stock; that when properly baked no gases escape, thus doing away with the need of venting, and such cores are much stronger than those made by the old method; that the iron is smoother, with sharp edges and corners; and that the sand does not adhere to the casting.

THE SUIT BROUGHT AGAINST THE CITY OF Rochester, N. Y., to set aside the proposals made several years ago by Moffett, Hodgkins & Clarke for constructing a part of the new water-works system has been decided in favor of the company. The complainants submitted a bid some $63,000 lower than any other competitor and the city awarded it the contract. The company claimed that its representative made a mistake in his estimates and wished to withdraw its bid. The city proposed to compel the company to do the work at the price named in its bid, or to sue for satisfaction on a $90,000 bond put up by the company. The court has decided that there is "clear, explicit and undisputed" evidence of a mistake in the estimates, and has issued an order rescinding the proposals and enjoining the city, as prayed for in the bill.

SOME $800,000 DAMAGES were awarded the city of Tacoma, Wash., in 1895, for deceit and fraudulent misrepresentations in connection with the sale of works of the Tacoma Light & Water Co. to the city. The State Supreme Court reversed the decision of the lower court on the ground of insufficient evidence, but on a rehearing has affirmed the decision. The city claimed that the yield of certain springs was not over 2,500,000 gallons per day, gravity supply, instead of the 10,000,000 claimed by the company; that the amount of pipe was over-stated, and the value of the whole plant misrepresented to the extent of $1,000,000; also that certain members of the city council were corrupted by the company in its attempts to effect the sale at the price paid.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred Sept. 5, on the Maine Central R. R., about two miles west of Etna, Me. Reports state that one person was killed, eight seriously injured and 24 slightly hurt. The train was an excursion, made up of five coaches and a combination car. The breaking of a flange threw the combination car from the rails and overturned it. The panic among the passengers is said to have been responsible for many of the injuries.

THE BURSTING OF A HUGE FLY WHEEL is reported at Portsmouth, O., as a result of the rolls slipping while handling a 4,800-lb. ingot at the Burgess Steel & Iron Works. Owing to the inability of the governor to control the increasing speed due to the sudden removal of the load, the large flywheel, weighing about 40 tons, flew to pieces. The mill was crowded with workmen, but only one man is said to have been injured.

THE BROOKLYN DRY-DOCK NO. 3, which sprung a leak last Spring, will be ready for use on Oct. 1, if the plans of Naval Constructor Bowles succeed. The cofferdam in front of the entrance is about completed, and it makes a dam aggregating 180 ft. in length and cost about $50,000. It is said that Mr. Bowles has noted some advantages possessed by the Halifax dock, and he recommends their introduction into this dock.

A BLOCK IN THE CHICAGO RIVER was caused Aug. 29 by the steamer "City of Bangor," which was starting out for Buffalo with a cargo of 168,000 bushels of corn. The boat is one of the largest which comes into the river, being 385 ft. long and 45 ft. beam, and drawing 18 ft. 4 ins. aft and 17 ft. 1 in. forward with its big cargo, so that its keel was in the mud nearly all the time. The vessel grounded opposite Polk St. for four hours, keeping the bridge open all that time, and then it grounded over the Washington St. tunnel. The Washington St. bridge was swung between the masts so that traffic was carried on until the tugs got the vessel off, but in opening the bridge the floor jammed on the steamer's capstan and a part of the floor planking had to be cut away before the bridge could be swung clear. At Randolph St. bridge a cable got entangled with the screw and the bridge had to be kept open for about half an hour while this accident was being remedied. It took the "City of Bangor" from 7.30 p. m., Aug. 28, to 2.30 p. m., Aug. 29, to get through the Chicago River from the grain elevator to the lake.

A DAM FAILURE OCCURRED at Kilbourn City, Wis., on Aug. 26. Mr. G. M. Marshall, Superintendent of Water-Works, writes us, in answer to inquiries, that it is hard to tell who was the engineer or contractor. The dam was 1,100 ft. long and extended across the Wisconsin River, with about 15 ft. of water against it. It consisted of a series of log cribs filled with stone and sand, the cribs being badly anchored and left with very uncertain footing. In fact it remained unbroken longer than Mr. Marshall had expected. Now one section, about 60 ft. long, at the middle, is gone. The pond or reservoir behind it was 5 miles long, from 10 to 90 ft. deep and 50 to 1,000 ft. wide. The spillway was cut in the rock and had an uneven surface. The dam was built in the summer and winter of 1894-95, the opportunities of the fine summer and low water being lost by delays. Mr. Marshall says there was no direct cause of the accident, and he does not think the dam will be reconstructed very soon. The next high water in the Wisconsin River will probably complete the destruction.

THE DEVELOPMENT OF WATER POWER in connection with electric transmission is just now a favorite subject for promoters. A scheme is on foot, in Richmond, Va., to utilize the power of James River. It is estimated that some 50,000 HP. could be developed. The local press is advocating a similar development of power on the Savannah River, near Augusta, Ga.; and based upon an investigation made by Capt. O. M. Carter, U. S. Engineer. It is estimated that 50,000 actual horse-power could be secured. In New York State, one of the latest schemes in this direction proposes to take water from the Chemung River, at Big Flats, and lead it to Horseheads and thence down the valley to Seneca Lake. The difference in grade between Elmira and Watkins, on the proposed route, is over 412 ft. in 23 miles; and between Pine Valley and Millport the fall is 129 ft. in 3 miles, while from Millport to Havana the fall is 314 ft. in 6 miles.

A DAM ACROSS THE MISSISSIPPI RIVER at Minnehaha Park, to furnish power for St. Paul and Minneapolis and for the improvement of navigation, has been under discussion for some time. The U. S. Government proposed three locks at this point originally, but lately have changed to two. Some of the leading men in both cities have taken the matter up and are now negotiating with representatives of the United States for a single structure, as outlined above, built jointly by the two cities and the General Government. Mr. J. T. Fanning, M. Am. Soc. C. E., of Minneapolis, has made a survey and a report upon the project.

A WESTERN WATERWAYS CONVENTION is to be held in Davenport, Ia., Oct. 5 and 6. The last similar convention was held in Vicksburg, Miss., in 1895. The chief purpose of the present convention is to prepare and submit to Congress a memorial asking for continued and more liberal aid in securing better permanent navigation in the rivers and harbors of the Missouri, Ohio and Mississippi valleys. The circular of the Executive Committee states that in the 1,250,000 sq. miles of the area drained by the Mississippi River and its tributaries are 15,410 miles of navigable and utilized waterways. In the 1,059 miles of river lying between Cairo, Ill., and the Gulf of Mexico are 1,305 miles of levees; and the railways, with their local connections, paralleling the levee system, aggregate 2,993 miles of track. Fifty-four counties, in seven states, border the river with a population of 1,235,884, according to the last census. The crops of corn, cotton and sugar in these counties have an estimated value of $48,169,288.

THE CONTEST FOR SUPERVISING ARCHITECT of the Treasury Department has brought out, so far, 75 applications for examination. This examination ends Sept. 10; but the immense number of papers filed with the Civil Service Commission may require some delay for their examination. The papers and plans forwarded by one applicant are said to fill a box 6 × 4 ft.

A LARGE PILE CONTRACT was recently awarded to two Michigan lumber firms by McArthur Bros., the contractors for the foundations of the new Chicago Post-office. This will involve the cutting of 6,000 Norway pine piles between 50 and 60 ft. in length. The land from which the piles will be cut lies on either side of the Ontonagon branch of the Chicago, Milwaukee & St. Paul Ry., which will naturally facilitate shipping. It is estimated that fully 400 car loads will be required to fill the order.

THE BALTIC & NORTH SEA CANAL TRAFFIC in the two years since it was opened falls far short of the estimates made by its promoters. The official statisticians of the German Government who made estimates upon the canal traffic before the enterprise was undertaken, figured the annual traffic at 5,560,000 tons and the receipts from tolls amounting to over 4,000,000 marks. The actual returns show that in the first year the traffic was 1,505,983 tons and the receipts 897,451 marks; in the second year the traffic was 2,036,861 tons and the revenue 1,086,432 marks. It is said that the patronage by sailing vessels is much larger and that by steam vessels much smaller than was expected by the statisticians.

BRIDGE OVER WISSAHICKON CREEK, FAIRMOUNT PARK, PHILADELPHIA.

By Joseph Wood Wagner, Jun. Am. Soc. C. E.*

Ever since the construction of the drive along the Wissahickon Creek by the Fairmount Park Commission, of Philadelphia, the creek has been crossed at a point just below Shur's Lane by a wooden bridge known as the Red Bridge, a Howe truss structure, which inadequately fulfilled the requirements levied upon it by increasing travel, and was also an unsightly object, out of harmony with its picturesque surroundings.

When it became necessary to replace this bridge on account of the rotting of the timber chords the Commission decided to erect a single span stone arch bridge, which, while affording a roadway of sufficient width to accommodate traffic, would be a structure of a design enhancing rather than marring the picturesque landscape. The design and construction of the stone arch present no very unusual features, but they are of such a character as to merit a short description, the general design being best illustrated by the accompanying photograph.

STONE ARCH OVER WISSAHICKON CREEK, FAIRMOUNT PARK, PHILADELPHIA.
Gen. Russell Thayer, Chief Engineer Fairmount Park Commission.
F. A. Stewart, Engineer in Charge. Michael McManus, Contractor.

The bridge crosses the stream obliquely, the abutments being placed parallel to the direction of the creek, making the angle between the longitudinal axis of the bridge and the abutment wall 69° 26'. This skew is taken up in ten arch rings, each 4 ft. wide, by placing the faces of the ribs parallel to the longitudinal center line and setting one corner of each 1 ft. 6 ins. back from the face of the abutment wall at the springing line. The span of each ring is 106 ft. 6 ins., making the clear span of the arch 105 ft., with a rise of 11 ft. from the springing line to the crown, the radius of the arch on the intrados being 134.4 ft. The springing line is but 6 ft. above the surface of the normal water in the stream, and this coupled with the flat arch is rather a remarkable feature. Starting at the skewback, the arch stones are 4 ft. 6 ins. deep, decreasing toward the crown to 3 ft. at the key, the width of the stones averaging 15 7-16 ins. on the extrados and 15 1-16 ins. on the intrados. Provision is made for a roadway 25 ft. in width and two sidewalks 5 ft. wide in the clear, all paved with asphalt. The bridge is finished, as shown by the photographs, by a parapet wall with dressed coping, posts and caps.

The specifications called for Conshohocken, Stockton, Hummelstown or other stone of equal quality, and it is in this connection that a local stone heretofore but little used in similar structures, was introduced and proved by its behavior an adaptability for this kind of work. It is a gneiss, rather dark in color, composed chiefly of quartz and hornblende, and contains little or no mica. The quarry is situated about half a mile from the bridge site, on Rittenhouse Street, Germantown, thereby recommending the use of this stone on account of facility in transportation and more especially as the contractor for the construction of the bridge controlled the quarry. From the location of the quarry the stone is known as Rittenhouse stone. Upon the approval of the engineers, Conshohocken stone was used in the ashlar of the abutments, spandrel filling and body of parapet wall, while the Rittenhouse stone was used in the arch ring, dentals and coping and posts of the parapet wall. The backing and filling is of large rubble masonry in which both stones were used. All the ashlar of the bridge is quarry-faced with an inch chisel draft on the faces of each stone, making a 2-in. draft at each joint. This dressing and its general effect is clearly shown in the accompanying photographs.

A comparison of tests made on the above-mentioned stones will show their relative merits as far as may be derived by small specimen tests; Conshohocken stone—crushing test on 2-in. cube: On natural bed, 64,250 lbs. or 16,060 lbs. per sq. in.; across natural bed, 42,400 lbs. or 10,600 lbs. per sq. in. Rittenhouse stone—crushing test on 2-in. cube: On natural bed, 80,300 lbs. or 20,075 lbs. per sq. in.; across natural bed, 89,000 lbs. or 22,250 lbs. per sq. in.

Attention is called to the peculiarity of the Rittenhouse stone in that its strength across the natural bed exceeds that on the natural bed. Its specific gravity is 2.837, absorption of water 0.21%, and tests for effect of frost showed a loss in strength of 0.03%. Although hard, this stone works well under the tool, takes a fine finish, and is susceptible of a high polish.

The bridge crosses the stream in a gorge, whose sides are composed chiefly of a micaceous gneiss rock, affording excellent foundation for the abutments and a natural wall to receive the thrust of the arch. In laying the foundations for the abutments, excavations were made until a satisfactory rock bottom was reached, then leveled up with concrete composed of 1 part Rosendale cement, 1 part sand and 3 parts 2-in. broken stone. Concrete was used as water was encountered, the stream being diverted by a rough dam of sheet piling, protecting the foundations from the direct current only. Above the concrete large rubble was used. The skewbacks were carried back in dressed stones on the line of thrust till a solid foundation was formed against the vertical rock by pockets cut out or built up. This portion of the work was well bonded with the large rubble filling.

Work on the bridge was begun in the spring of 1896, but owing to delay in obtaining the stone, the majority of the cut stone work was set up during the following winter, when it was subjected to some extremely cold weather. To provide for these conditions the arch stones were dressed for neat joints, steamed and dried before setting, and the sand and water used in the mortar were thoroughly heated. The arch rings were laid on a centering supported by piles driven in the bed of the creek.

Hemmoor brand Portland cement was used in setting the stones of the arch rings and the ashlar of the abutments, and a Rosendale cement was used in all the other work. The backing and filling was thoroughly grouted for every 2½ ft. as the masonry progressed in height with a grout composed of 1 part cement and 2 parts sand. Special care was observed in mixing and excellent results obtained. Immediately after setting the key stone, the arch centers were struck and the whole ring settled uniformly, amounting to 1⅛ ins. at the crown and gradually decreasing toward the haunches. No further settlement has been noted.

Notwithstanding the unfavorable conditions under which this work was carried on, no evidences of cracking or spalling are perceptible beyond those noted on any masonry work subjected to close scrutiny. The bridge was completed and handed over to the Commissioners of Fairmount Park in May, 1897.

The Wissahickon Bridge was designed by the Engineer Corps of the Fairmount Park Commission, General Russell Thayer, Chief Engineer, and from its conception to final completion has been under the immediate supervision of Mr. F. A. Stewart, Engineer in Charge. The contract for the construction of the bridge was awarded to Mr. Michael McManus, Philadelphia, the lowest bidder. The cost of the completed structure, including the removal of the old bridge, was $27,743. In the accompanying view of the bridge the remains of the abutment of the old bridge can be seen on the left.

The writer's acknowledgments are extended to General Russell Thayer, Chief Engineer, for permission to use the bridge as a subject for this paper; to Mr. F. A. Stewart, Engineer in charge, for the greater part of the information contained herein, and to Mr. Lewis R. Snow, who took the photograph of the completed structure from which the illustration has been prepared.

*Bureau of Surveys, 512 City Hall, Philadelphia, Pa.

THE PRECISION OF ELECTRICAL ENGINEERING.*

By Francis B. Crocker, Pres. Am. Inst. Elec. E.†

There still exists quite a general idea that electricity is so imperfectly understood that its laws and actions are little more than matters of chance or guesswork. This notion is not confined to the ignorant, but is believed by many educated persons, even including our brother civil and mechanical engineers.

The existence of this popular error concerning electricity is perfectly natural, and arises from the novelty of the subject and the fact that its development has been so great and so rapid that no one but a few specialists have been able to keep pace with it. During the present year the president of a large steam railroad system, on which electric propulsion is being tried, publicly expressed his opinion that electrical engineers know little or nothing of their subject. In legal decisions in this country and abroad, judges have stated that electricity was so vaguely understood that testimony concerning it was of no practical value.

The idea that "no one knows what electricity is, therefore we know practically nothing about it," is often expressed by those who want to excuse their own ignorance

*Extracts from the inaugural address at the fourteenth general meeting of the American Institute of Electrical Engineers, Eliot, Me., July 26, 1897.
†Pres. Am. Inst. Elec. E.

of the subject. Their deduction is quite natural, but is absolutely fallacious. While we must admit that we do not know the real nature of electricity, the same limitation of knowledge applies to all other fundamental facts. Gravitation is the most familiar of natural phenomena, yet we have no conception whatever of what it actually is.

Our theories and mental pictures of the nature of electricity are much more definite than those concerning gravitation. In regard to the latter, little progress has been made since the time of Newton, while electrical knowledge has advanced and is now advancing with giant strides. There is every reason to believe that we shall "know what electricity is" and be able to explain the inherent mechanism by which electrical actions take place before we understand how and why a stone is drawn to the earth.

The popular ignorance and doubt concerning electricity is rapidly disappearing in consequence of the remarkable results accomplished by it during the last ten or fifteen years, but it will not be out of place, I think, to consider at this time the remarkable exactness which electrical engineering has reached. A discussion of this question may serve to inform laymen who are not familiar with the facts, and may also be a matter of interest and satisfaction to ourselves. This profession has only very recently gained for itself a position of independence and equality among the branches of engineering, but it can now fairly claim to be an example for the others to follow, not only in the magnitude and rapidity of its results, but also in the exactness and certainty of its methods. Let us consider what are the principal facts upon which this strong claim is based.

The Names Connected With Electrical Science.—Gilbert, Franklin, Faraday, Ampere, Maxwell, Henry, Helmholtz, Kelvin, and a long list of other distinguished electricians are not men whose ideas are vague or incorrect. Indeed, it is a significant fact that the ablest and most profound scientific men have been attracted by and have performed some of their best work in the study of electricity.

The rapid progress of electrical science and its applications is an absolute proof of sure and exact knowledge. Uncertainty would necessarily cause delay, and error would involve repeated trials before success could be reached. The fact that the difficult arts of long-distance transmission of power and electric traction have been developed to their present state of importance and success in about ten years, shows conclusively that electrical theories and designs agree very closely with the actual facts.

The great results accomplished by electrical engineering is probably its strongest claim. Many of these are so unique and astonishing that we still regard them with wonder even after we have become familiar with them. Among the most striking of these examples are the locating of faults on submarine cables, telephoning a thousand miles or more, transmitting power over one hundred miles, sending simultaneously a number of messages on the same wire, utilizing the power of Niagara and producing the Rontgen ray. These and hundreds of other wonderful feats are not accomplished by chance or by groping in the dark.

The close relationship between pure and applied electrical science is still another proof of the exactness and truth of both. If knowledge were complete, theory and practice would become identical. The agreement between theoretical and practical electricity is largely due to the small losses which occur in electrical apparatus and processes. Even quantities which correspond to friction in mechanics, such as electrical resistance and magnetic hysteresis, are capable of exact calculation. It is only the purely non-electrical factors, such as the friction of bearings and air resistance that are uncertain in designing electrical machinery. The almost infinite rapidity of electrical action makes the time element so small that it can almost always be neglected. This greatly simplifies calculations and renders their results more accurate. The fact that there is only one kind or quality of electricity also gives definiteness to our ideas and calculations. With coal we must know its quality, including both its physical and chemical properties, in order to make even approximate calculations concerning it. In the case of steam, pressure and volume are not sufficient data; the amount of moisture and superheating must also be known.

This power to solve problems successfully by a priori reasoning demonstrates the perfection of electrical science. We can arrive at the facts by reasoning out what they ought to be; hence we may say that electrical science is ideal. In other branches of applied science, as for example in civil engineering, the corrections, factors of safety and other allowances are often much greater than the original quantity itself. In such cases it is obviously impossible to go very far from an experimental fact by any process of reasoning. The errors would immediately become so magnified that the truth would be greatly distorted or lost entirely.

To take a concrete example, the losses in transforming electrical energy are only 2 or 3%, and if an error of 10% is made in calculating these losses, the actual error is only 0.2 or 0.3%. It would, therefore, be possible to design a system in which electrical energy was transformed many times, and yet the final error would only be 1 or 2%. If, on the other hand, the losses in mechanical engineering are 10 or 20%, or even 50%, as is often the case, an error of 10% in calculating these quantities would soon become multiplied to a large figure.

Exactness in electrical units and terms is another strong point of electrical engineering, because definiteness in terms and ideas go hand in hand. The system of electrical units is complete and scientific, being based directly upon the C. G. S. system, and is the only example of a set of units which are universally adopted. The metric system is not in use in the United States, England and her possions and many other countries, but the same electrical units are accepted by all nations. This avoids the great confusion which arises from the use of several different units for the same thing, as is the case in steam engineering, in which at least four different heat units are commonly employed.

The enormous range in electrical engineering is still another proof of its precision. The same laws and principles which apply to the almost infinitesimal galvanometer current are equally applicable to the current from an electric light station. The former may be only a hundred billionth of an ampere and the latter reaches 10,000 amperes, which is a thousand million million (10^{15}) times greater.

An even greater range than this represents the range of resistance measurements. In the case of large copper bars, a determination to within .000001 ohm is often required, and for insulation testing 10,000 megohms is not an unusually high figure. This gives a range of measurement of ten thousand million million (10^{16}).

An electrical instrument, the bolometer of Prof. Langley, is used to measure the heat received from the fixed stars, and electricity is also the agent selected when 100,000 horse-power are to be distributed from Niagara. Instead of saying that electricity is selected for these extreme uses, it would be more correct to state that it must be employed, just as it is the only means of transmitting speech a thousand miles, or performing the many other miracles of which it alone is capable.

The directness and high efficiency with which electrical energy can be converted into other forms is another fact which gives exactness to our work. It can be transformed into heat, light, magnetic, mechanical or chemical energy by the simplest means, and conversely, the latter forms, with the possible exception of light, can be readily exchanged into electrical energy. In most cases the conversion is almost perfect, the efficiency of an electric motor or dynamo being usually over 90% and often 93 or 94%. The electrical energy in a storage battery represents nearly 90% of the watt-hours applied to it, assuming the losses in charging and discharging to be about equal. The storage of magnetic energy may be effected at an even higher efficiency of 97 or 98%, and the conversion of electrical energy into heat is complete, the efficiency of an electrical stove actually reaching the ideal figure of 100%. The production of light cannot be accomplished so economically, nevertheless, the arc lamp has a far higher efficiency than any other source of artificial light, although it is usually stated to be only 8 or 10%. It is also more than probable that the long-sought-for high efficiency lamp will be an electric one when it is finally invented.

The facility and accuracy of electrical measurements contributes greatly to the precision of electrical engineering. Volts and amperes can be easily, quickly and accurately measured by means of convenient portable instruments. The product of these volts and amperes gives the watts or power which is the most important quantity.

If desired, a single instrument—the wattmeter—can be used to combine the two quantities. Electrical resistance can also be measured easily and quickly, and with still greater accuracy. Even the less common electrical quantities, such as capacity and inductance, can be measured without much difficulty and with reasonable exactness. The magnetic quantities are also quite easily and correctly determined. As already stated, the most doubtful factors in electrical engineering are the mechanical ones. In this connection I quote from information kindly furnished me by one of the vice-presidents of the Institute, Mr. A. E. Kennelly, who has had a long and successful experience in this branch of the profession. He says:

> In the case of cable coiled in a tank and which has been taken into the tank over a measuring drum without being subjected to any considerable tension, the precision with which a fault in the gutta percha can be located is sometimes very considerable. I have known one or two cases in which a fault has occurred in a length of, say, thirty miles of cable immersed in water and maintained at practically one temperature in the tank, and in which, by means of the Varley loop test repeated many times and under various conditions to eliminate constant errors, the electrical position of the fault has been determined to within a probable error, representing about twenty feet of length. On turning the cable over from one tank to another by a seven foot drum on which the cable makes three turns, and cutting the cable when the computed distance has been run over, the fault has been found on the drum, that is, in the sixty feet or so of cable then lying on the drum.
>
> As regards the location of faults in submarine cables on the ocean bed, the precision depends upon a variety of circumstances, and in general is necessarily much lower than in the case of a cable coiled in a tank. The average error in practice, or the difference between the true electrical and computed positions, is perhaps about fifteen ohms, or about one mile and a half of cable having the common resistance of ten ohms per mile.

I remember being informed by Mr. Gano S. Dunn several years ago that he had found by experience in many cases that the efficiency of a direct current dynamo or motor can be predetermined from the drawings before the machine is built, within a fraction of 1%; in fact, he relied more upon his calculations than upon an actual test of the completed machine, even when performed by skilled men. In one case the calculated efficiency was 93%, and the result obtained by test was 92.7%, and in another case the total flux was found to be 1.38% greater than the computed value. This agreement is somewhat closer than is found in every day practice, but is not accidental and can usually be approximated by careful work.

We naturally suppose ourselves to be familiar with mechanical energy and heat; but as soon as we convert these well-known forms of energy into that extremely subtle and mysterious agent—electricity—it immediately becomes far more definite and convenient to control, measure, transmit and utilize. In becoming intangible, it forthwith acts as the most reliable and matter-of-fact tool in the hands of those familiar with it. For example, the quickest, neatest and most exact method of making a test of mechanical friction, or the power required in any given case is by the use of an electric motor. In this way, for example, we can determine the friction of different bearings or lubricating oils under various conditions of pressure and speed, or the power consumed by fans, pumps and other machines.

Quite a striking example of the possibilities of electrical measurement is the determination of the E. M. F. of a dynamo machine without running it, which I saw successfully carried out more than ten years ago. All that is necessary is to measure the torque exerted by the machine with a given current in its armature. This may be accomplished by simply clamping a stick of wood to the pulley and weighing the pull at a given radius by means of a spring balance. If the same machine were run as a dynamo and had no losses, it follows that

$$\frac{E\,I}{746} = \frac{2\pi r S P}{33{,}000},$$

whence

$$E = \frac{r\,S\,P}{7.40\,I},$$

in which r is the radius at which the pull is measured, S is the speed in revolutions per minute at which the dynamo is to be run, P is the pull in pounds at the given radius and I is the current in amperes. The field strength is supposed to remain the same. This method is correct whatever the efficiency of the machine may be. The electrical and magnetic losses due to the $I^2 R$ effect in armature, field current, eddy currents and hysteresis do not enter this problem. Even the mechanical losses arising from friction of bearings, brushes, etc., may be eliminated by measuring the pull plus the friction and then minus the friction, the actual pull being one-half the sum of these two results. The effect of friction may also be gotten rid of by tapping the shaft when the measurement is made. It certainly strikes one as strange that E. M. F., which depends upon cutting lines of force, can be determined while the machine is standing still.

In electro-chemistry and electro-metallurgy quantitative relations are particularly precise. The ampere being defined as the current which deposits .001118 grammes of silver per second, the weight of any other substance is by Faraday's laws proportional simply to its chemical equivalent.

Since the weights of materials liberated or consumed by a given current in a given time can be definitely predetermined and the voltage due to a certain chemical combination can be accurately calculated, almost any problem in electro-chemistry or electro-metallurgy is susceptible of being quite easily and correctly solved.

That branch of electro-chemistry and metallurgy which employs electrical heating methods is also very definite, the exact amount of heat in gramme-degrees produced (per second—Ed.) by an electric current being always given by the simple expression 0.24 I^2 R, or 0.24 E I.

In support of the proposition advanced in the title of this address, I am able to produce most interesting personal testimony. Mr. Edison and Mr. Tesla have independently expressed to me their opinion that electrical knowledge had become so definite and general that almost any one could apply it, and comparatively little opportunity was left for invention. They believed that chemistry and thermodynamics were far more uncertain and therefore offered a much better field for improvement. These views were expressed several years ago, and subsequent events have shown that they contain a great deal of truth.

ELECTROLYSIS IN CHICAGO.

An investigation as to electrolytic corrosion of water pipes, etc., caused by the return current from the electric railways, has been made by Mr. Edward B. Ellicott, Superintendent of the City Telegraph Department, Chicago, Ill., and the result is given in the following letter submitted by him to Mr. L. E. McGann, Commissioner of Public Works:

> I have had an examination made of the ground return of the street railway company operating an electric railway

line on South State St., with the following result: At the corner of 51st and State Sts. a test was made between a 30-in. gas pipe and the rails of the street railway company. It showed there was a current of 25 amperes flowing from the pipes to the rails at a point where this large main was intersected with a 6-in. gas pipe at 51st St. In the block between 50th and 51st Sts. there was found to be a difference of potential of three volts between the hydrant and the rails, and a current flow of 16 to 20 amperes. Between 51st and 52d Sts., near which latter street is located the power-house of the street railway company, there is a gradual decrease in current flow, which shows that the ground return at a point on 51st St. and State St. is very poor.

The railway company should be required to run the proper return wires from this point in order to decrease the flow of current from the pipe to rails. The 6-in. gas pipe which was removed was found to be very badly pitted from the action of the current, and it is no doubt affecting the water mains in this vicinity and at other points along the line which have not as yet been tested.

The difference of potential between the rails and the gas and water pipes should be reduced to practically nothing in order to prevent the deterioration of the pipes. I do not know of any other way of securing this result, except to run the proper sized copper return cables and make connections to the rails at such points that it will prevent the flow of current between the pipes and the rails; or to connect the pipes to the rails at different points along the line and give the current a path to the rails through a good connection.

I would not want to recommend this latter method without first making some very careful and extended tests. There is no doubt that within the next year or two it will be necessary to replace many of the water mains, owing to their being affected by carrying the street railway return current, and I am of the opinion that a complete test should be made of all the street railway lines which parallel water mains with a view of determining where the dangerous points are, and that the railway companies be required to remedy the defects in the return conductors.

I would suggest that a competent man be detailed for this work and the tests be made at an early date in order that the railway companies may have an opportunity to correct the defects before winter. The test above referred to was made with a representative of the South Chicago City Railway Co. present, and their reports will probably show the same results as above given.

THE CROTON AQUEDUCT EMBANKMENT.

By H. K. Landis, E. M.

Among the Harlem improvements of New York city may be noted the extension of Burnside Ave., westward, which has necessitated the piercing of the Old Croton Aqueduct; the driveway will, when finished, be under the aqueduct, which will be supported by an arch spanning the avenue. The cut through this famous piece of engineering work has exposed the section of embankment, as shown in the accompanying view, which is interesting, not only on account of its connection with such an important enterprise, but more so by reason of the amount of discussion on its design it aroused, at the time and since.

It will be remembered that the water supply previous to the building of this aqueduct was provided by the Manhattan Co., whose principal wells were

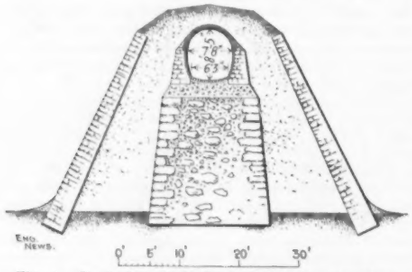


Fig. 1.—Typical Section of the Old Croton Aqueduct Embankment.

located at City Hall Park and 13th St.; the latter well was the best producer and had a daily capacity of 20,000 gallons at the beginning of this century. The extortionate water rates and poor water furnished by the company, which, by the way, was organized by Aaron Burr, more as a banking scheme than for water supply, induced the city to explore for other sources. On Nov. 10, 1832, Col. De Witt Clinton was directed to investigate a source of water supply, and on Dec. 22 he reported in favor of the Croton River, differing from all other surveyors in this choice. In Jan., 1833, the Common Council prepared a bill which was passed by the State Legislature on Feb. 26, and the Commissioners were appointed at once by the Governor. Surveys were begun by Maj. D. B. Douglass, and the next year, 1834, by John Martinian, the Croton survey being accepted by the city in the spring of 1835, and work begun with Major Douglass in charge, as chief engineer. Although his location was accepted the plans and specifications adopted were made by his successor, John B. Jervis. The grade was 13¼ ins. per mile, though at some points it was but 6 and 9 ins. On July 2, 1842, the work was completed, and remains as it was finished, with a few minor repairs, an efficient water carrier after 55 years' of service.

The accompanying section will explain the construction adopted for the 125 embankments along the line, aggregating five miles, and varying from 100 to 14,000 ft. in length, and from 10 to 40 ft. in height. The outside or face walls are of masonry having uncemented stone in the base to allow drainage. Loose small stone, sand and gravel fill the interstices of the stone forming a foundation wall for the conduit; there was neither cement nor mortar of any kind used in this foundation. It was capped, however, by about 15 ins. of concrete, upon which the masonry retaining walls of the conduit were built; the spandrels were also filled in with masonry while the inside was lined with brick laid in cement. All the space between and above was filled with earth. This aqueduct supplied New York city with water until the new one was completed.

For a period of twenty years after the aqueduct was in operation there was considerable trouble experienced by leakage. It was soon discovered that a number of cracks had developed in top and bottom. When not very serious they were closed temporarily by throwing clay and sawdust into the conduit and letting the percolating waters carry them to the cracks; but when these cracks became larger the entire aqueduct was shut off, and the cracks cemented, necessitating a loss of service of about two days. These cracks occurred in the high embankments, those 10 feet or less giving no trouble; transverse cracks, due to settlement, first appeared, and after a time longitudinal cracks in top and bottom became common.

The longitudinal cracks were by far the more dangerous, and the remedy not very apparent, so long as experts differed so radically as to their cause. It was found that this conduit and others before it had a strong inclination to become wider; this widening in other conduits was as much as one to six inches. So the outer face walls were built to the present height, and a decided improvement noted. It may be interesting to look at some expert opinions as to the cause of these longitudinal cracks in both top and bottom. All agree that they are caused by the spreading laterally of the conduit, but differ as to the cause for such movement.

Some attributed it to the action of frost in permitting the earth to settle away from the conduit side and thus allow the thrust of the arch to act against less resistance. Or, that thawing on one side alone would produce like results. It was observed that the top of the face walls, after a time, had fallen inward about two inches, that they had spread at the level of the bottom of the conduit about 2½ ins., and spread at the ground surface 1½ ins., indicating an undoubted movement

FIG. 2. SECTION OF EMBANKMENT OF OLD CROTON AQUEDUCT AT BURNSIDE AVE., NEW YORK CITY.

of the foundation and the earth filling. Others observed that natural settling is aided by the action of the percolating water either in causing the dry wall foundation to compact itself or by making its earth support soft. They assert that the combination of a rigid and an earth support is bad, and that if the foundation were solid masonry with stronger retaining conduit walls, it would not crack.

It is very probable that these cracks were caused more by freezing of the adjacent earth than by vertical settlement. Their remedy would seem to lie in making the concrete bed twice as thick, and in adopting a section which would hold together when filled with water without the aid of the side filling of earth. The objection to this is the increased cost. To judge from the history of other similar conduits, cracks in high embankments seem inevitable up to a certain age, just as railway embankments settle and spread out laterally. One earth conduit embankment which caused troublesome cracks was improved by making it broader, thus retaining it in a measure. Practically all new embankments will spread laterally upon thawing after freezing, making it necessary in railway work to go over the track and take out the crooks caused by lateral movement. We can then naturally infer a lateral shrinkage of earth upon thawing which will cause the two walls of earth on either side of the conduit to shrink away from it and the face wall; the latter will follow up such shrinkage, and by the action of gravity compress it downward, causing, as before noted, the top of the wall to incline inward, and making it bulge a few feet further down.

The condition of the work is otherwise excellent, and if free from the action of frost would probably be as long-lived as its famous Roman progenitor. The concrete is firm and the masonry in good condition, so that it really does seem at first glance that a more expensive construction would scarcely have been justified at that time.

THE CONSUMPTION OF ALUMINUM in the United States in 1896 amounted to between 600 and 700 tons, according to a statement by Mr. Alfred E. Hunt, M. Am. Soc. C. E., President of the Pittsburg Reduction Co.

PAINTING BUILDINGS BY COMPRESSED AIR.

In the Michigan Engineers' Annual for 1897, Mr. J. J. Hubbell describes the application of oil paint to large buildings by means of the air-brush. These buildings belong to the Buckley & Douglas Lumber Co., and included a main building 475 ft. long by 356 ft. wide. The structures covered about five acres and there was fully 1,000 "squares" or 100,000 sq. ft. of surface to be covered with paint. Rough hemlock lumber was used in the sides of these buildings, and the problem was to cover this siding with some preservative compound as cheaply as possible. After a full consideration of various washes, a mixture of good raw linseed oil and red oxide of iron was determined upon.

Bids were received from three local painters. One of these offered to furnish brushes and ladders and to apply the paint for 35 cts. per square; another offered to do it for 28 cts. if the company provided all material, and the third made a lump bid of $300 for providing labor alone. Each of these bids was reasonable, but all of the painters deemed two coats necessary and thought the season too far advanced to undertake the work at that time. In this emergency Mr. Hubbell determined to use compressed air for the work.

He made his own sprayer at a cost of $10, and in addition provided 150 ft. of ¾-in. hose, an air-pump taken from a locomotive and an air reservoir also taken from a locomotive. This latter had a capacity of 10 cu. ft. and was placed near the large building and connected to the air pump by ½-in. gas-pipe. He says that he should have used ¾-in. pipe, but the smaller pipe was on hand in quantities. Of the hose, 125 ft. were to connect the nozzle with the air reservoir and 25 ft. to connect the nozzle with the paint-bucket, the latter being elevated to about the level of the nozzle.

The paint came in barrels of 50 gallons each, and to each head of these barrels was screwed an iron flange with a short journal attached. The barrel was hung on these journals and revolved by a crank so as to thoroughly mix the paint, which was then drawn off by a molasses gate set in the side of the barrel, two or three gallons at a time. In use the air pressure ranged from 40 to 50 lbs. and as the air passed through the nozzle it sprayed the paint in a fine cloud looking like a jet of red vapor. The discharge was controlled by a valve in the base of the nozzle and the operator soon became expert and could paint 8 or 10 feet above his head and the same distance below his feet. Two men were required, one to keep the paint bucket full and the other to handle the brush. There was little waste of paint, though every crevice was filled, and the rough surface was covered better than it could have been done by hand. One gallon of paint would cover about 150 sq. ft., and the two men could cover about 5,000 sq. ft. in one day. The windows were protected by a light moveable canvas-covered frame.

The cost of the oil paint thus applied did not exceed 10 cts. per 100 sq. ft., and the cost of painting the buildings, including all labor and a reasonable sum for the use of the air-pump, pipe, reservoir and brush, was less than 15 cts. per square of 100 sq. ft., or less than one-half the cost of painting by hand.

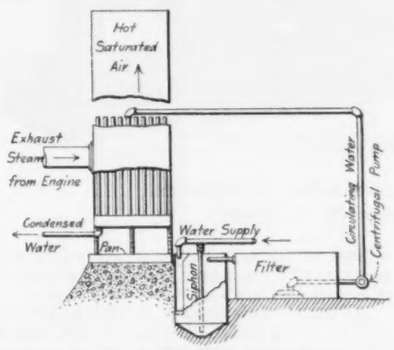
EXAMINATION FOR INSPECTORS UNDER THE NEW ORLEANS DRAINAGE COMMISSION.

The following set of questions were prepared by Mr. B. M. Harrod, President American Society of Civil Engineers, for candidates for the position of inspector upon the new drainage works of New Orleans. The questions are quite elementary, but will doubtless interest a number of our readers. The candidates were required to show the details of their calculations:

1. Reduce 10½ ins. to decimals of a foot.
2. Express 17⅝ ft. in yards, feet and inches.
3. Multiply 2 3-16 by 24⅝.
4. A wall is 100 ft. long, with end sections as shown (here follows a diagram). What is its contents in cubic yards?
5. A concrete foundation measures 100 ft. by 75 ft. in plan, by 3 ft. depth and includes three (3) circular pits, 4 ft. iniameter and 2 ft. deep. How many cubic yards does it contain?
6. A concrete pavement measures 12 ft. 5 ins. in width at one end and tapers to a point at the other, the perpendicular distance between point and end being 28 ft. How many square yards does it contain?
7. A line of sheet piling 6 ins. thick, is 100 ft. long and consists of three thicknesses of plank each measuring 2 ins. by 12 by 23 ft. How many feet B. M. does it contain?
8. How many feet B. M. in the following bill of lumber?
   Six pieces; dimensions 8½ ins. by 12 ins. by 20 ft.
   Seventeen pieces; dimensions 3 ins. by 16 ft. by 19 ft.?
   Eighty pieces; dimensions 3¾ ins. by 8½ ins. by 10 ft.?
   Nineteen pieces; dimensions 2 ins. by 4½ ins. by 16¾ ft.?
   Four pieces; dimensions 8 ins. by 8 ins. by 20 ft.,
   Eleven pieces; dimensions 4 ins. by 6 ins. by 30 ft.?
9. Round wrought iron rods are to be paid for by the ton of 2,000 lbs. Give the cost of 500 rods, 9 ft. long, 1¼ ins. diameter at $63.33 per ton.
10. A circle is 8 ft. in diameter. What is the length of its circumference, and what of the four sides of the inscribed square?
11. Give the weights of a cubic yard of average brickwork and concrete.
12. State in the order of importance the defects to be guarded against in the following materials: Lumber, piles, bricks and cast-iron?
13. How is good cement mortar made?
14. How is good concrete made?

AN AIR-COOLING SURFACE CONDENSER.

A new form of surface condenser, designed by Mr. Arthur Pennell, of Kansas City, Mo., is illustrated herewith. It is of the type known as evaporative condensers, in which the cooling fluid is air saturated with moisture. As will be seen from the illustration, it consists of a shell, containing as many 4-in. tubes as can conveniently be inserted, supported on four legs standing in a shallow pan. The shell is continued upward, in either thin sheet-iron or wood, to a suitable height, thus forming a flue. A centrifugal pump circulates a volume of water, as shown, and, by a suitable arrangement on the upper tube-plate, the water is caused to form a film over the entire internal surface of the tubes, while descending. When exhaust-steam enters the shell, the tubes and internal surface film are heated, the latter vaporizes into the air in the tubes. As hot saturated air is lighter than the atmosphere, an upward current ensues, the velocity of which depends on the natural draft due to the height of the flue, and on the difference in weight between the atmosphere and the hot saturated air, less the friction. For every pound of water vapor thus formed and carried off in the saturated air, a pound of steam condenses in the shell. The condensed water, as fast as formed, either flows off against atmospheric pressure, or is withdrawn by a suitable vacuum pump.



A New Evaporative Condenser.
Designed by Arthur Pennell, Kansas City, Mo.

The temperature at which condensation occurs, and the consequent vacuum obtainable, depends on the volume of air passing up; the greater the volume of air, the lower the temperature of saturation. The surface required can be distributed among numerous short tubes, if a high vacuum be desired, or the tubes can be comparatively fewer and longer as may be demanded. The advantages of the surface-condensation of exhaust steam can thus be obtained for no greater water-supply than when the engine is run non-condensing, and the current expense is only for running the circulating and vacuum pumps. The settling tank and filter shown are useful accessories in localities where the water supply is charged with mineral salts that would form scale in the tubes.

A DUTCH COMBINED BUCKET, SUCTION AND LAND-FILLING DREDGE.

The Russian government has lately put into service, at the port of Theodosie, in the Crimea, a marine dredge which combines the ladder, or bucket dredge, suction pipes and pumps, and a line of pipes on pontoons for filling in land. This dredge was designed for work in the different ports of the Sea of Azof, and was built by the Smulders Company, of Rotterdam. The following general description is taken from "Le Genie Civil," of May 2, 1897:

The length of the steel hull is 150.88 ft.; beam, 27.22 ft.; depth of hull, 10.66 ft.; maximum draft, 7 ft.; speed in knots, 8½. The dredge has twin screws and is fitted to navigate the open sea, having made the trip from Rotterdam to Theodosie in 23 days. The ladder dredge works in a central well in the after part, located between the two screws; and chutes are arranged to deliver the spoil into barges alongside; or this material can be delivered directly upon the bank, at some distance away, by means of two centrifugal pumps and a line of floating pipe. The ladder is sufficiently long to dredge to a depth of 22 ft.

Besides the steam winches and special motor for electric lighting, the machinery of the dredge includes three identical motors, two of which are coupled and either operate the land-filling pumps, or the screws for the propulsion of the vessel. The third motor works the chain of dredging buckets. All of these engines are of the compound, surface-condensing type, of 200-I HP. each. The high pressure cylinders have a diameter of 14⅞ ins.; low pressure, 26⅝ ins.; and the stroke is 15¾ ins. Two Russian marine boilers supply the steam to these engines, with power sufficient to operate both the motor engines and the steam winches. An auxiliary vertical boiler operates the electric light motor and supplies steam for heating purposes.

The land-filling pumps have a capacity of 325 cu. yds. of sand or mud per hour delivered 1,640 ft. from the dredge and 5 ft. above the water level. These same filling pumps can be utilized for directly sucking up the material from a depth of 22 ft. through a suction pipe located outside the hull in the forward part of the vessel. This suction arrangement has a capacity of from 325 to 338 cu. yds. per hour in sand or mud, and it delivers either into scows or into the line of floating pipe. This suction pipe can be lifted entirely out of the water and offers no resistance in navigation. All of the machinery is operated from the bridge from a covered cabin, heated by steam and lighted by electricity. Two are lamps, of 1,500 c. p. each, permit working at night. The cost of this boat and the name of the designing engineer are not given.

CENTRIFUGAL PUMP DREDGES IN NEW SOUTH WALES.

In a paper upon "Centrifugal Pump Dredging in N. S. Wales," read before the Engineering Section of the Royal Society of N. S. Wales, Mr. A. B. Portus, Assoc. M. Inst. C. E., describes some of the earlier centrifugal pump dredges. He says that the first successful application of the centrifugal pump for this purpose was on the Amsterdam Canal, in 1867. As the canal was to be deepened from 3 ft. to 23 ft., mechanical appliances became necessary, and Messrs. Burt and Freeman fitted an improved Woodford centrifugal pump to an old bucket dredge. In this pump the shaft was vertical and drove a "spinner" 3 ft. 6 ins. diameter, fitted near the bottom of an upright cylinder 12 ft. high, so arranged that the contents of the buckets falling through it were met by the ascending column of water from the Woodford pump. The silt, thus liquified, was forced to the shore through buoyed wooden pipes connected by leather sleeves. As much as 2,000 tons of silt was sometimes thus delivered in 12 hours, and deposited 8 ft. above water level at a distance of 1,200 ft. from the dredge.

Double machines of this type were used early in 1870 on canal work at Cronstadt, Russia. Mr. Burt further improved his machine by fitting knives on the vertical pump shaft and by directing

into the cylinder water jets under high pressure. He thus succeeded in dealing with stiff clay and introduced the improved machine on the Danube. In 1880 the Barron Ship Building Co. constructed for use on the Danube a combined bucket and pump-dredge, 124 ft. long, 28 ft. beam, and provided with buckets holding 18 cu. ft. each, and capable of working to a depth of 28 ft. In this boat the pump was 4 ft. 6 ins. diameter, the pipes were 18 ins. diameter. With both buckets and pump working the engines developed 180 HP., and Mr. Portus divides the work as being probably 55 HP. for dredging and 125 HP. for pumping.

The next application of the sand pump, says the author, was to the steam hopper-barges, used by the Dutch contractors, Messrs. Volker and Bos, in deepening the seaports of Rotterdam and Amsterdam. He does not describe these, but says that they were substantially of the same type as the dredges used by the government of New South Wales in Sydney Harbor, the necessary machinery for these latter, with some improvements, having been obtained from Messrs. J. and K. Smith, the chief builders of sand pump-dredgers in Holland.

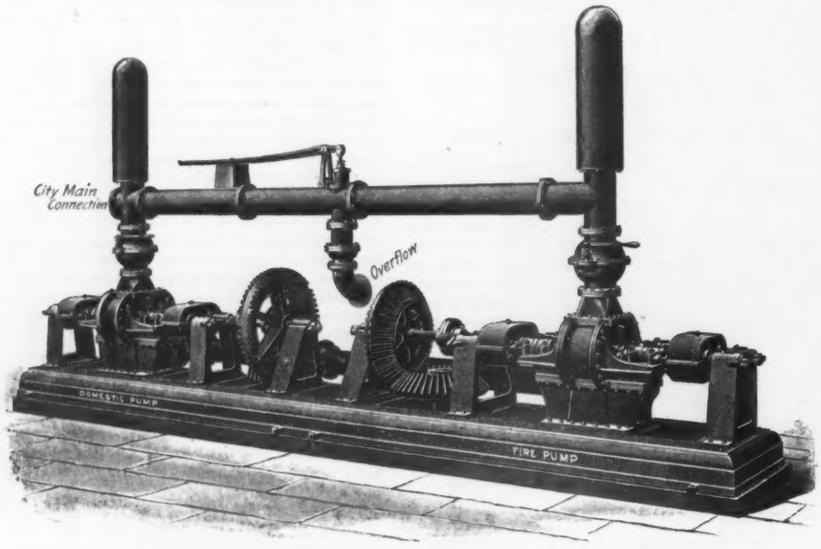
Briefly described, the "Neptune" dredge here referred to was originally a steam hopper dredge of 400 tons capacity, with a hull 148 ft. 3 ins. long, 24 ft. beam and a draft, light, of 8 ft. This vessel had been used for carrying silt to sea, and for towing dredge-barges. The hull was first lengthened 12 ft., to gain additional freeboard and to carry more silt and provide more space for the machinery. The engines were of the compound surface condensing type, capable of developing 330 I. HP., with steam at 80 lbs. pressure. The pump was placed forward of the engines, and fore and aft of the engines were fitted suitable clutches by which the power could be applied either to the propeller shaft or the pump, at will. Between the engines and the pump was a friction clutch, so adjusted that it would slip if stone or other material was drawn into the pump and endangered the spindles. The hopper held 500 tons of sand, and suction and delivery pipes were 20 ins. diameter; and with a "spinner," 6 ft. 6¾ ins. diameter, making 130 revolutions per minute, this hopper was filled in 19 minutes under favorable circumstances.

Mr. Portus says that the periphery speed, 2,680 ft. per minute in the above case, was increased about 18%, if the material were sent through pipes 1,500 ft. long. When pumping into the hopper a much higher percentage of sand is delivered than when sending the material ashore. He assumes that 1,800 ft. may be taken as the profitable limit for heavy sand; but silt may be sent by the same pump twice as far.

Mr. Portus says that the average cost of lifting 2,043,564 tons of sand and mud by the "Neptune" was about 4.9 cts. per ton, and the average cost per hour of pumping was $8.16. With the "Juno" dredge, built on the same general design as the "Neptune," in 1890-95, the cost of lifting 2,478,498 tons, almost all sand, was about 4 cts. per ton, and average cost of pumping per hour was $8.78.

ROTARY PUMPS FOR WATER-WORKS SERVICE.

The use of rotary pumps in mills and factories has become very common, and their merits for fire service especially are generally recognized. The use of pumps of this class for a town water supply, however, is something unusual, and considerable interest attaches, therefore, to the report of experience with two rotary pumps which have been in service nine years at Connersville, Ind.



ROTARY PUMPING PLANT, CONNERSVILLE, IND., WATER-WORKS.
P. H. & F. M. Roots Co., Connersville, Ind., Builders.

The pumps were installed in 1888 by the P. H. & F. M. Roots Co., of Connersville, and their general arrangement is shown in the accompanying illustration. As there shown, two pumps, one for ordinary service, and one for fire service, are mounted upon the same base with pipe connections to admit of either pump supplying the mains. The driving power is transmitted from the turbines below through bevel gears to the respective pump shafts. Each pump has a capacity of 7 gallons per revolution, but they are run at different pressures. The domestic service pump is used, as its name implies, to supply the city mains at a pressure of from 45 lbs. to 60 lbs. per sq. in., and is driven by a 30-in. Victor turbine with a 22-ft. head. The other, or fire pump, maintains from 100 to 120 lbs. per sq. in., requiring a 50-in. Victor wheel under the same head. The advantage claimed for these pumps by the makers is that the absence of rubbing parts and of all valves would make the cost of repairs very small. The piston in these rotary pumps, it will be remembered, revolves very close to but out of contact with the casing. The absolutely uniform motion of the water in the supply and delivery pipes is also a manifest advantage.

We are informed that during the nine years these pumps have been running no repairs whatever have ever been made upon them until recently, when new shafts were put in to replace the old ones which had become worn out at the stuffing boxes.

While the renewal was in progress measurements were made which revealed the fact that the revolving pistons had worn only .03-in. during the nine years of service. It should be stated further that the water pumped was taken from the White Water River which, notwithstanding its name, is heavily charged with sediment during freshets following heavy rains.

NOTES FROM THE ENGINEERING SCHOOLS.

University of Illinois.—The practical work done by the Mechanical Engineering Department under Prof. Breckenridge, has included a series of tests of locomotive performance in regular service. The series comprised 22 tests made on one passenger and two freight engines on the Illinois Central R. R., the passenger runs being between Chicago and Champaign, and the freight runs between Centralia and Champaign. The railway company granted the use of the engines, and they were equipped, under the direction of Mr. Renshaw, Superintendent of Motive Power, with the pyrometers, indicators, gages, calibrating apparatus, etc., furnished by the University. A crew of six students attended to the apparatus and records, indicator cards being taken at the rate of one a minute, and these cards showed a good steam distribution at high speeds. Experiments were made with different forms of exhaust nozzle, and records were made of the fuel and water consumption, etc., on each run. Future tests will probably be made relating to individual matters of detail, such as the effect of different arrangements of load, etc.

The University is now putting in a new central heating plant for its ten buildings, to replace the two present plants, under an appropriation of $80,000 from the State Legislature, for establishing a central station for heat, light and power. A brick tunnel or subway 6 ft. 6 ins. high and 6 ft. wide has been built to connect the various buildings, and in this will be laid the pipes for heating, ventilating, compressed air, etc., and the electric wires. This plant, which will be very complete, has been designed by Prof. Breckenridge.

Massachusetts Institute of Technology.—The new catalogue of this institution describes 13 separate four-year courses. Six of these are distinctively engineering courses, viz.: Civil, mechanical, mining and metallurgical, electrical, sanitary, and chemical engineering. Besides these there are complete four-year courses in physics, in chemistry, in architecture, in naval architecture, in biology, in geology, and in "general studies." The last-named is a course designed for students who wish to secure an education based upon scientific study and experiment, but including a larger amount of history, economics, language, and literature than is possible in technical courses. It is adapted to the needs of those who expect to engage in trade, banking, manufacturing or journalism, or in the teaching of social or political science.

The International Correspondence Schools, Scranton, Pa., have greatly extended their list of courses, which now includes mines, mechanics, steam engineering, electricity, architecture, plumbing, heating and ventilation, civil engineering, railroad engineering, bridge engineering, municipal engineering, hydraulic engineering, English branches, bookkeeping and stenography, and sheet metal pattern drafting. A "circular of information," recently issued, gives particulars of the method of teaching by correspondence, and another pamphlet contains 1,000 testimonials from students.

RECOVERING A LINE OF 24 AND 30-IN. CAST-IRON WATER PIPE AT BOSTON.

By Frederic I. Winslow.*

The changes in street grades incidental to the abolition of grade crossings at the railroad terminal in South Boston, rendered necessary the relaying, in an entirely different location, the large water mains supplying a portion of South Boston, thus throwing out of service about 900 ft. of 30-in. and about 550 ft. of 24-in. pipe.

This line was laid in 1895 in a soil consisting of clay to the level of the top of the pipe, and about 3 ft. of gravel above this. The grade of the bottom of the pipe was about 1 ft. above high tide. It was decided to raise the pipes for future use, the line taking the place of the abandoned one having been laid before the old line could be removed.

The work was given to a local contractor who was to raise and separate the pipes, and remove them to the pipe-yard, two miles distant. Care was to be taken to save all the lead possible, and the pipe could not be cut more frequently than once in 60 ft.

*Engineering Department, city of Boston.

The method employed was to uncover the pipe the entire length to a level just below the center of the pipe, then to excavate around each alternate bell and burn out the joint. It was impossible to maintain a fire under the pipe on account of the water in the trench, but it was found that after burning out the upper half of the joint it was comparatively easy to pull out the two lengths of pipe, after the insertion of blocking near the burned-out bell, and allowing the open part of the pipe to settle, thus disturbing the set of the lead.

The pipe lay in 12-ft. lengths, weighing 3,700 lbs. in the case of the 30-in., and 2,600 lbs. each in the case of the 24-in., so that each piece pulled out weighed respectively 7,400 and 5,200 lbs. The joints were about 2½ ins. deep, and from ⅜ to 7-16-in. in thickness. There was a bead on all the spigot ends of the 30-in. pipe, and a score in the bells of both the sizes .

The amount of wood used per joint was about 20 cu. ft. Kerosene was dashed on the fire frequently and each fire was carefully watched and the joints prodded with an iron instrument to ascertain how near to being burned out the joint was, the fire being hauled aside as soon as the proper time came. Every precaution was taken to avoid overheating the pipes, as well as to avoid sudden cooling. The intermediate joints were burned out on the bank. The amount of lead saved was 5,000 lbs., or about 75% of the amount originally used, the remainder being mixed with dirt and lost. But one length of 24-in. and a 6-ft. piece of 30-in. pipe were thrown aside, as they were cracked in unloading. The entire work was performed at a cost to the contractor of $1,957, or $1.34 per ft. About $200 of this amount might have been saved by more careful planning in excavating, or the work might have been done for $1.20 per ft. No attempt was made to separate the cost of the different sizes. At present prices this pipe is worth, not allowing for deterioration, about $4,000, and the lead recovered about $175, making the net credit on the work about $2,000. Fifteen working days were occupied in performing the work, which was done in June last.

In connection with the above interesting record of experience we are able to present an account of a similar piece of work in which, at the suggestion of one of the editors of this journal, a Wells light was used for melting the joints. The work in question was done under the direction of Mr. S. W. Frescoln, C. E., and we are indebted to him for the following account of it, prepared at our request:

The main you have in mind was an old 24-in. pipe line in Lancaster, Pa., about 5,000 ft. in length, and depths varying from 4 to 20 ft., a portion being located upon the incline of an exceedingly steep hillside. The pipe was first uncovered, and an attempt made to melt out the joints with wood fires, but was almost immediately abandoned as being too expensive and wasteful, requiring a cord of wood at $6 per cord for two or three joints, besides oxidizing more than half the lead in the hot charcoal. A Wells light was then rigged for the purpose. The vertical stand-pipe was taken off, and by means of a sufficient length of flexible rubber hose and fittings, two burners were attached to the cylinder containing the oil, so that the cylinder could be placed upon the pipe, and a burner be operated upon two joints at once. The constant services of one man were required to operate the burners, and compress the air in the oil cylinder. By means of suitable tongs and rigging made from ordinary stiff wire, the flame from each burner, about 2 ft. long ordinarily, under a blast of 30 lbs., was directed at very short range exactly against the lead joint at the top of the bell. After an interval of half an hour or more, the lead at the top of the joint would melt and run down the sides and drop upon the ground clean and bright, with no appreciable loss by oxidation. The work then proceeded with more apparent rapidity, the burner being lowered on either side of the pipe until all the lead of the upper semi-circumference was removed. The work on the joint was then completed, as the lower semi-circumference of lead in nowise prevented the spigots of one pipe being withdrawn from the hub of the other by the derrick in raising the pipe from the ditch. The average speed made was from 8 to 10 joints per day per man, and 1 bbl. of oil sufficed for about 12 joints. The man was paid $1.50 per day, and the oil cost 6 cts. per gallon in barrel lots, so that the cost of melting out the joints was about 5 cts. per lin. ft. of pipe, allowing for repairs, etc. The lead obtained from the work was my property, and averaged 50 lbs. per joint, and was utilized in relaying the main elsewhere, and 2,000 ft. of pipe additional. As a comparison with the wood method, it may be stated that the wood method cost 10 cts. per ft. to melt out the joints, allowing for lead saved 5 cts. per lb., while the method adopted made a profit of 15 cts., which meant a saving of $1,250 over the wood method for the 5,000 ft. It can also be stated that this process is practical in cases when wood cannot be employed at all, viz., when the pipe has water in the lower half. For when wood is employed the lower part of the joint melts and the water leaks out and extinguishes the fires. Yours respectfully,

S. W. Frescoln.

Reading, Pa., Aug. 16, 1897.

VARIATIONS IN THE COST OF STEAM POWER.

At the recent summer convention of the American Institute of Electrical Engineers, a paper with the above title was read by Mr. H. A. Foster, which is not only the latest but one of the best discussions of this subject that has ever appeared. Until a recent date the question, what is the cost of steam power? has been of comparatively little practical importance; but the success of the electric transmission of power and the installation in hundreds of places of water-power plants distributing electric current at low cost have made the cost of steam power a very important matter and one on which engineers are very frequently called on to give an opinion.

The principal point brought out by Mr. Foster's paper, and one which deserves more attention than it has ever received, is that the cost of steam power is an exceedingly variable quantity. We often see statements that in such and such a locality the cost of steam power averages so many dollars per HP. per annum, and estimates of the profit to be made in electric power transmission enterprises are based on such statements. The fact is that one might as well attempt to say what the average cost of a wagon was without specifying the kind of wagon as to state the average cost per annum of a steam horse-power. The cost of coal, the kind of coal, the size of the plant, the character of the machinery, the use to which the power is applied, the character of the load, the number of hours' service per annum, the ability of the engineer and the firemen—all these and many other variables affect the cost of a horse-power, and as a result in large plants using the same kind of coal, the cost of power may vary by 50% or more, while in plants of 300-HP. and under the cost of a horse-power may be four to six times as great in one case as in another.

The proof of this statement, given in Mr. Foster's paper, may be briefly summarized as follows: Mr. Foster made actual tests of 22 different power plants, including a variety of manufacturing establishments, electric light stations, pumping engines, etc., and determined for each the power consumption per annum and its cost, including in the latter, not only the running expenses, but the fixed charges, classified under the heads of interest on the first cost, depreciation, taxes and insurance. The cost per horse-power per annum varied from a minimum of $15.69 to a maximum of $233.95. The accompanying table, which we have compiled from the results given by Mr. Foster, arranging the results according to the size of the plants, shows the variation in detail.

Table Showing Average Power Developed and Its Cost per HP. in 22 Steam Power Plants.

Output.—Average HP. developed.	No. of days pr annum.	Operating expenses, per HP.	Fixed charges, per HP.	Total cost, HP. per annum.	Cost, Pr HP. hr.,cts.
12.4	361	$147.93	$25.40	$173.33	5.048
20.9	365	123.12	28.42	151.54	1.868
21.5	361	90.47	17.80	108.27	2.918
32.9	330	22.56	5.83	28.39	.852
36.7	365	137.25	96.70	233.95	2.811
42.4	365	86.38	63.20	149.58	1.708
53.	309	56.94	19.51	76.45	1.598
58.8	365	97.30	33.82	131.12	1.613
70.4	365	101.60	20.78	122.45	1.641
120.3	365	30.14	9.41	39.55	.871
166.7	313	15.19	4.47	19.66	.639
173.	313	22.66	5.83	28.39	3.333
210.9	290	40.33	7.86	48.19	.693
296.7	297	45.56	7.81	53.37	.749
928.	307	11.73	8.77	20.50	.691
1,010.8	306	15.70	7.74	23.44	.704
1,174.8	306	10.19	5.50	15.69	.531
1,278.7	293	10.49	6.23	16.72	.500
1,345.5	365	23.28	9.42	32.70	.820
1,352.	365	33.03	20.41	62.44	.713
1,909.7	306	13.40	6.63	20.03	.677
2,422.	306	15.67	6.73	22.40	.757

To bring out still more clearly the facts stated above, we have plotted the results in the table upon a diagram which is presented herewith. A few of the results which appeared to be most abnormal were omitted, but it will be seen that even with this done the lines plotted are exceedingly uneven, especially for the smaller powers.

The irregular line marked A shows the variation in total fixed charges, and curve C represents the corresponding variation in operating expenses. The extreme irregularity of these lines below 300-HP. shows clearly that no true average can be selected. Above this power the peaks are smoothed out and both fixed charges and operating expenses approach the smooth curves B and D, which we have sketched as approximate averages of the lines A and C. Fixed charges are without exception less than operating expenses, as shown by A and C, and above 300-HP. fixed charges run quite uniform regardless of the size of the plant.

The rapid increase in the cost per horse-power, which ordinarily takes place as the size of the plant falls off, is well shown by that part of the diagram, between zero and 500-HP.

The upper smooth curve marked E is the sum of the ordinates of B and D, and represents a total average cost per horse-power per annum. From what has been said it is evident that this average is only a crude approximation, as all general averages of cost of steam production must be.

Even when a uniform type of steam plant is adopted, uniform prices for coal are assumed, and a plant of large capacity is taken, estimates of different authorities vary widely, as may be seen by the accompanying comparison compiled by Mr. Foster, from the principal published statements of the cost of power when developed in such plants as are common in the textile mills of New England.

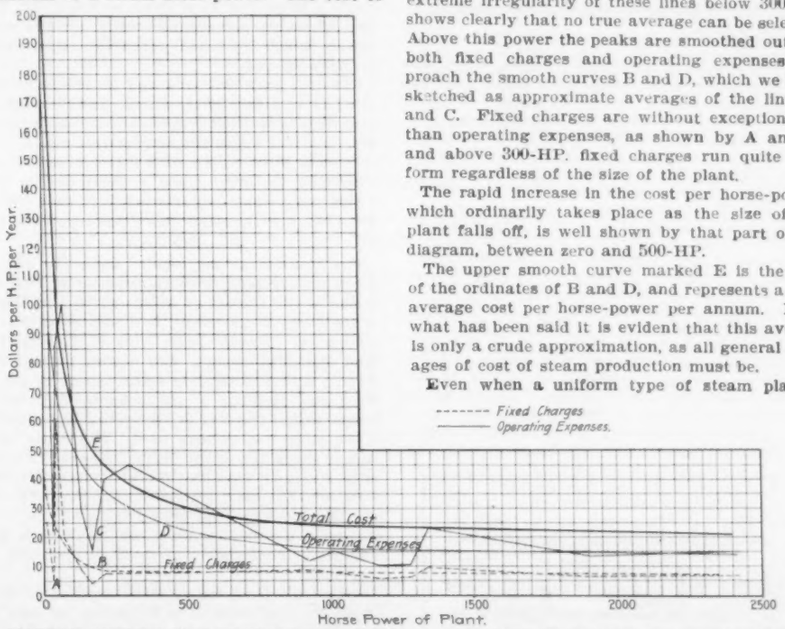


DIAGRAM SHOWING COST OF STEAM POWER PER HP. PER ANNUM IN VARIOUS ESTABLISHMENTS.

Comparison of Different Estimates of the Cost of Steam Power Developed by Large Compound Condensing Engines, Cost of Coal taken in all Cases at $3 per net ton, delivered.

	Cost, per HP. hour.
Emery, A. I. E. E., for 3,080 hours, table XX..	$0.00784
Emery, A. I. E. E., for 7,000 hours., table XXI..	.00617
Emery, "Engineering Magazine," 3,080 hours ..	.00856
Webber, 650 HP., 3,080 hours, table XXIV....	.00720
Webber, 1,050 HP., 3,080 hours, table XXIII....	.00646
Hale, 2,985 house, table XXV.....	.00557
Main, 3,080 hours, table XXVIII.	.00637
Foster, average, 3,080 hours, table XXV.	.00824
Average of all	$0.00705

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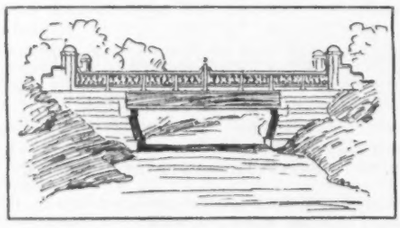
ADVERTISING RATES: 20 cents per line. Want notices, special rates, see page 28. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

One of the most beautiful pictures which has ever appeared in this journal is shown on page 162 of this issue, and is a fine example of good landscape engineering as well as good taste in bridge construction. While such a structure would not be out of place anywhere, it is eminently adapted to its location in Philadelphia's famous and beautiful park.

That a bridge structure in a park should be made of pleasing architectural design goes without saying; but it is only within recent years that the importance of this matter has begun to be generally recognized. In the parks of most of our older cities numerous examples are to be seen of bridges which transgress in one respect or another the well-accepted principles of artistic design, and the erection of structures that are an offence to the eye and a blot upon the landscape is not yet at an end. As an illustration of this we reproduce herewith a cut which appeared in one of our newspaper exchanges last month. It represents one of



three bridges which are soon to be erected in the parks of the city where the newspaper is published. Cuts of the three were published, but we select the one shown herewith as typical of the design of all. In each case a straight bald girder crosses the opening between two huge masses of masonry, built with a batter that compels the conclusion that the designer was in grave doubt of the ability of the abutments to stand alone. The whole is surmounted by an elaborately-ornamented railing and portals whose goodness or badness the newspaper sketch leaves much in doubt; but which are evidently out of all harmony with and desperately ashamed of the plain little girder at which they stand sentinel.

We forbear mentioning the name of the city whose parks are to contain these bridges; for it is possible that by this time some of its public-spirited citizens, with a knowledge of things artistic, may have entered a protest against this design and secured its amendment. If this be not the case, we trust this may still be done.

Very likely the designs for these bridges may be entirely sound from an engineering standpoint purely, and the designer may be merely uninstructed, or lacking in the aesthetic sense which enables one to distinguish between what is ugly and what is pleasing. But this is no reason why the designs should be allowed to stand. If the sketches can be trusted, a bridge from these designs would be quite as expensive as one that would be equally strong but far more pleasing to the eye.

The New York anti-scalping law, which went into effect on Sept. 1, and which prohibits the sale of railway tickets by any one not an authorized agent of the railway company, is said by the newspapers to be religiously obeyed by the scalpers, notwithstanding their numerous assurances prior to Sept. 1 that the law would make no difference whatever in the conduct of their business. The scalpers have arranged to ascertain the constitutionality of the law by the trial of a test case; but pending its decision they appear to intend to obey the statute.

The enactment of this law is a notable step in advance, and New York's example ought to be followed by other state legislatures. It does not injure the traveling public a particle—all the assertions of the scalpers to the contrary notwithstanding—for any passenger unable to use the whole of a ticket which he has purchased can have the unused portion redeemed upon presentation at the railway ticket office. On the other hand, it stops a large leak in railway revenues due to the use of stolen and counterfeited tickets, and of tickets which have had punch cancellations filled or dates altered.

The free pass evil was and is generally recognized as an injury to the public, and the legislation against it is just and proper; but the scalping business is a still worse offender against public policy. It is only by stopping such leaks in railway revenue that the great mass of the traveling public which has to pay full fare when it uses the railways can hope to make its journeys at lower rates.

The transfer of the repairs upon the damaged Brooklyn dry dock, from the Bureau of Yards and Docks to the Bureau of Construction and Repairs, of the Navy Department, is a somewhat startling innovation. Naval Constructor F. T. Bowles has been placed in charge, with almost unlimited authority, and directions to make use of all the material and facilities of the Bureau of Yards and Docks, and to transfer to his bureau any employees of the other that he may need. This order by Assistant Secretary of the Navy Roosevelt is practically a victory for Chief Naval Constructor Hichborn, who has long contended that the supervision of all dry docks should belong to his bureau; and it may pave the way for some radical changes in the conduct of government methods in dry dock construction.

But in thus condemning the Bureau of Yards and Docks the Department is betraying its own past lack of business methods in the management of that bureau, and is reaping, in unsatisfactory work, the results of bad organization and unprofessional control. This journal has long contended that in the Navy, as elsewhere, engineers alone should be placed in charge of engineering work; and the one thing to be deeply regretted in this last move of the Navy Department is the unwarranted and unjust imputation cast upon the ability of the real civil engineers in the Bureau of Yards and Docks. The Civil Engineer Corps of the U. S. Navy counts among its older members engineers of long experience and of the highest professional repute; and to hold these men responsible for faulty design and methods of construction, over which engineers have had no actual and final control under the organization of the Bureau of Yards and Docks, is manifestly unjust and is an undeserved slight to the engineering profession. Had this bureau been handled, in the appointment of its Chief, as are all the other staff bureaus of the Navy Department, without exception, we should undoubtedly have had little to complain of as to our government docks, and the government itself would not have experienced the mortification of being compelled to use the dry dock of a foreign nation for ordinary repairs to a United States battleship. The failures in the methods of dry dock construction are not, therefore, chargeable to the lack of ability in the civil engineers of the Navy, but to an iniquitous system of controlling these engineers.

As to the permanent transfer of dry dock construction to the Bureau of Construction and Repairs, there is indeed something to be said. In favor of that proposition is the fact that this bureau is headed by a most able man who, unlike the head of the Bureau of Yards and Docks, has been in continuous employment in the direct line of his profession for over 28 years. Mr. Hichborn was appointed from civil life, as were the four officers of the bureau next in rank to himself, and they are all men who understand their business, and consequently their opinions are deserving of respect in all that pertains to their business. With these five exceptions, all the other Naval Constructors and Assistant Naval Constructors in the Bureau of Construction and Repairs are graduates of the Naval Academy, and the majority of them, we believe, have supplemented this education by a special training abroad. But these men have not built dry docks; and however complete may be their theoretical knowledge of construction of this type, they lack the experience and that intimate knowledge of controlling conditions that only come with years of practical work. Admitting the superior abilities of the chief of the Bureau of Construction and Repair, we still contend that the engineers in the Bureau of Yards and Docks are better fitted to deal with the problems of dry dock construction, for the immediate present at least, than the inexperienced and untrained staff of the bureau which is now seeking to control this work. But, if past practice in selecting a Chief for the Bureau of Yards and Docks is to continue, it would be far better to deprive that chief of the power of doing mischief by cutting down his responsibility to the lowest limit. Then all the naval engineering work of the government should be placed under one bureau headed by a competent engineer; the particular title of that bureau is not essential.

"The Formation of Cavities in Water by Screw Propellers at High Speed" was considered in a paper read by Mr. Sidney W. Barnaby, M. Inst. C. E., at the recent International Congress of Naval Architects and Marine Engineers. Particular attention was called to the phenomenon of "Cavitation," which had been observed by Mr. Parsons in his experiments with the "Turbinia," and by the author and Mr. Thornycroft in 1895 in trials of the "Daring." Whenever the speed of a screw increases beyond a certain point the water appears to be detached from the forward face, leaving a vacuum, and when this takes place the efficiency of the screw rapidly diminishes. Mr. Barnaby has found that the maximum thrust which can be obtained from a screw working at a depth of 11 ins. below the surface is reached when the total thrust divided by the projected blade area is 11¼ lbs. per sq. in. (0.75 atmosphere). This figure has been corroborated by the experiments of Mr. Parsons. The author thinks that "cavitation" will certainly be the cause of trouble in the future. Already, he says, it is becoming difficult to obtain the requisite area of screws in torpedo destroyers without either resorting to an abnormal width of blade or to a larger diameter and pitch ratio than could otherwise have been preferable. The one expedient gives undue surface friction, and the other necessitates a reduction in the rate of revolution, and therefore a heavier engine.

FASTER AND HEAVIER FREIGHT TRAINS AND ECONOMICAL FREIGHT MOVEMENT.

The remarkable record of the Chesapeake & Ohio R. R. in the movement of freight at low cost, is one which deserves to be studied by every engineer interested in the problem of cheap transportation.

This road now possesses the distinction of hauling the largest average freight train load, and of moving bulk freight at the lowest rate per ton mile of any railway in the country, or, for that matter—since American freight rates are far below those charged by the railways in any other country—of any railway in the world.

In its annual report, recently issued, this company shows an average freight rate per ton per mile, on all classes of freight, of only 4.19 mills. On its coal traffic, which forms a large percentage of its business, the average receipts were 2.97 mills per ton per mile; and in the previous fiscal year its coal was moved at an even lower rate than this, the average for the year being only 2.53 mills per ton per mile. And yet, notwithstanding these low rates the company earned enough to pay its operating expenses, the fixed charges on a bonded debt amounting to about $50,000 per mile, and had besides this $302,541 surplus from the results of last year's business.

The secret of this remarkable result is found, without doubt, in the extent to which the average freight train-load has been increased. In the last fiscal year the average freight train-load on the entire system was 352 tons. This is even better than the record of the Lake Shore, which has long been noted for its progressiveness in the matter of increasing train loads. In the year ending Dec. 31, 1896, the Lake Shore freight train-load averaged 322 tons.

The large train-load of the Chesapeake & Ohio is the more remarkable, as is also the very low cost at which its bulk freights are moved, when the grades of the line are considered. It is true that large sums have been expended in improving the grade of the road, but two summits, each over 2,000 feet high, have to be crossed in moving freight from the Ohio River to the seaboard over this route; and as on any railway in a mountainous country, a large part of the alinement is curvature. Further, the line is nearly all single track. Yet, over this road last year freight trains carrying an average load of 352 tons were moved, earning on an average only $1.47 per mile run, but nevertheless paying the entire expenses of operation, maintenance and interest charges, and leaving a balance to the good.

If such a railway can accomplish such feats in the low-cost movement of freight, what limit shall we set to the cost of freight-carriage on a low-grade double-track railway, located especially with a view to moving a great volume of through freight traffic at the lowest cost?

The advocates of ship canals from the Great Lakes to the Hudson and to the Ohio, should give careful consideration to these results of actual experience in railway freight traffic, and to the unmistakable signs that the decrease in the cost of rail transportation has by no means reached its end.

We occasionally see the statement made that the decadence of river and canal transportation in this country is due to the failure to improve our navigable waterways, and that the great volume of traffic which still follows the internal waterways of France is due to the lavish expenditure which has been made upon them. Whatever truth either of these statements may contain, they both overlook the fact that American railway freight rates are far below those of any other country in the world.

Would French river and canal traffic have maintained its volume if French railways had kept pace with American in reducing the cost of freight carriage? Would the unfortunate Manchester ship canal ever have been undertaken if English railways had been able to transfer freight from the Liverpool docks at prices as low as American railways are accustomed to charge?

Of course no one questions that on the open ocean or on the Great Lakes a modern vessel can carry bulk freights at less cost than will perhaps ever be possible on a railway, even at its highest development. But it must not be forgotten that in any contracted channel the cost of water transportation rapidly increases. In any canal enterprise undertaken at the present day, the possibilities of railway competition should be weighed with all possible care. If this question is merely brushed aside with a few glittering generalities, a mistake may be made for which those who invest in the enterprise will pay dearly.

Apropos of the question of economical freight transportation, we believe that one factor in the reduction of the cost of freight movement, which is not always properly appreciated, is the great increase in freight train speeds which has taken place in the past ten years. It used to be considered the proper thing to move freight trains at slow speed over the road. Fast freights were considered a luxury, and only defensible when competition made them necessary, in order to secure business. Probably the idea that it was wasteful to run freight trains at high speed originated in the old fallacy that train resistance increased very rapidly with increase in speeds. This fallacy was firmly fixed in the minds of railway trainmen, and officials as well, by the small boilers which were the rule on all locomotives until the 80's. With these small boilers and grates a freight locomotive was unable to pull a fair-sized train at considerable speed, whereas there was usually cylinder power enough and adhesion enough to keep a train moving if the speeds did not run up above 15 to 20 miles per hour. What was more natural than to conclude from this that the train resistance increased very rapidly with increase in speed!

But when railway managers awoke to the fact that big train loads were the secret of economical operation, the boiler and the grate of the freight locomotive began a rapid growth. The fast freights which were originally put on only under stress of competition taught some valuable lessons in economical traffic movement.

Suppose the resistance of a train running 40 miles per hour is 50% greater than when running 20 miles per hour. It does not by any means follow that 50% more coal will be burned by the locomotive, or that the tonnage of the train will be cut down 50%. The train running at higher speed can pass by its impetus over summits where the slower train would be stalled. The kinetic energy of a train running at 40 miles per hour is sufficient to lift it vertically 57 ft. At 20 miles an hour the stored energy would lift it only 14 ft. It can run down long grades without wasting energy by applying the brakes. The resistance of the locomotive and tender is the same for a short train as a long one, hence the added resistance of the additional number of cars is not proportional to the actual increase in the length of the train.

These and other considerations, as well as actual experience shows that the additional cost of fuel for running freight trains at high speed, rather than low speed, is no very great amount. On the other hand we can consider a modern freight train as a huge machine, costing perhaps $30,000. It requires a crew of five or six men to operate it, whose wages may amount to $1.25 to $1.50 per hour. Why should it loaf along at 12 or 15 miles per hour, if it is capable of running 20 or 30? Suppose it does take a little more coal; suppose the boiler wears out a little more rapidly, the difference in the interest charge on the equipment and in the wages account will far outweigh this.

The danger of accidents may be cited as an objection to fast freights; but on well-managed roads, properly signalled and with trains equipped with M. C. B. couplers and air-brakes, there should be no question as to moving freight trains of sound cars at speeds rising to 40 miles per hour with safety. It will not be overlooked either by the careful manager that a smaller equipment will suffice for a road which works its engines and cars "for all they are worth" than for a road which moves trains at a slow pace.

An excellent example of modern practice has come to our notice as we write. The Baltimore & Ohio Southwestern, within the past fortnight, ran two trains, one weighing 732 and the other 734 tons, from Cincinnati to Parkersburg, 200 miles, in 8 hours and 3 minutes, and 8 hours and 4 minutes respectively. The run from St. Louis to Cincinnati, 340 miles, was made in 16 hours. The excellence of this record can be better appreciated when it is stated that some of the grades of the line are steeper than 1 per cent.

We have alluded above to the effect of reduced cost of freight carriage upon the competition of railways with water routes. The increased speed of freight trains is also an important factor in this connection. It is acknowledged, even by the advocates of water transportaion, that slow movement prevents any inland waterways from competing with the railway except on the cheapest class of bulk freights. Even on bulk freights, however, quick transit is becoming more and more a consideration to the shipper. Wheat is rushed to market to take advantage of a sudden rise, and before a reaction occurs. Iron ore is called for by furnaces to meet sudden demands of the market that have not been anticipated. Coal is urgently needed at some points where the ordinary source of supply has been cut off by strike. Because the railway can respond to such demands as these, it is bound to come into favor more and more with shippers of bulk freights, even when the rates are somewhat higher than would be charged by a competing water route.

LETTERS TO THE EDITOR.

Tension in Spokes of Bicycle Wheels.

Sir: President Metz, of the Waltham Manufacturing Co., in a letter published in the Engineering News of Aug. 26, says that the torsional pull of the chain on the rear hub of a bicycle has more to do with broken spokes than the rider's weight. When my weight was 195 lbs. I had the misfortune to break several spokes in my rear wheel, and in every case this occurred when the rear wheel passed over some obstruction. If only about half my weight was upon the rear wheel (say 100 lbs.), it appears to me the strain must be much greater than can possibly be applied by the pull of a chain, for even the hardest push on the pedal can never approach 100 lbs. stress on the hub due to the weight of the rider, and even this must be exceeded in the case of a sudden jolt. Yours truly, R. W. Pope.

New York, Aug. 31, 1897.

Bursting Strength of the Boiler Tested at St. Louis.

Sir: When I spoke of the counteractions of ringwise and axial strains in the St. Louis boiler, on page 106 of your issue of Aug. 12, I believed the axial tension of 36,000 lbs. per sq. in. to be below the elastic limit of steel of 60,000 lbs. tensile strength, and thought that a straight line might replace the elongation curve a considerable distance above the elastic limit. Supposing this, and remembering the irregular elongation near the breaking point, the possibility of the applied ringwise strains running up even beyond the normal breaking point, the influence of the axial tension on the ringwise elongation, which I pointed out in my letter, the change of elastic conditions by cold bending without annealing, and other influences, not mentioned—these conditions do not permit us to consider the tensile strength as equal to the applied ringwise strains as computed on page 14 of your issue of July 1. The St. Louis boiler was tested especially to determine the strength of riveted joints. The joints, as well as the plates, proved stronger than expected. If the test should be repeated I would suggest to measure the increase of two diameters of the boiler in order to determine the ringwise elongation corresponding to the increments of pressure applied, and to find out how much the so-called elastic limit of a steam boiler is higher than that of a tension test specimen. As far as I know the favorable influence of a combination of forces applied in two directions at right angles to each other has never been measured in a construction of large dimensions.

Yours respectfully, Th. Hoech.

German Embassy, Washington, D. C., Aug. 15, 1897.

The Civil Engineer Corps of the Navy.

Sir: In the current issue of Engineering News, in commenting upon the dry dock investigation, you say: "The discouraging feature about this whole investigation is that the subject is one that can only be handled by experienced and able engineers, and there is not an engineer on the board," etc. Might you not have said, "and there is not such an engineer in the navy," without exceeding the limits of truth?

"By their works shall they be judged," and the dry docks at New York, Port Royal and Puget Sound are lasting examples of how docks should not be built. They are valuable in this negative way, yet such experimenting is misleading and expensive. The Civil Engineers in the navy are well paid, the scale of wages being better than in the same relative places, arranged according to age, of civil engineers in civil life. This should at least insure us capable men.

At a competitive examination held in June for filling a vacancy in the Corps of Civil Engineers, U. S. N., there were two applicants appointed, neither of whom was a practical engineer, both, at the time of appointment, holding places in the departments of Washington as clerks. If that is the method of recruiting the corps the sooner the corps is abolished and the work let out by contract,

thus at least placing the responsibility, the better it will be for the citizens who pay the bills.

Respectfully yours, John Martin.

New York, Sept. 3, 1897.

(Before condemning the officers of the present civil engineering staff of the navy our correspondent should investigate the system which places these engineers under a non-professional Chief of Bureau. All plans must be approved by this officer; and his ideas and suggestions are law. These are unfortunate conditions for the successful conduct of any engineering work; and the effect of this system upon the plans for the dry-docks at Brooklyn and Port Royal have been fully set forth in this journal. The civil engineers of the Corps are all right; but they need a civil engineer chief who can appreciate engineering advice, and second their efforts to obtain good and sufficient plans, and a proper conduct of work.

As a matter of fact the Civil Engineer Corps of the Navy includes some very able engineers. The two young men appointed to the corps recently, after a competitive examination, are both graduates of Troy Polytechnic Institute, and if they held clerkships in Washington at the time of their appointment, as our correspondent alleges, that is certainly nothing against their abilities as engineers.—Ed.)

Notes and Queries.

H. C. C. writes: "Will you please give me directions for making the 'boiling test,' as recommended by the American Society of Civil Engineers, in testing for soundness of Portland cements? I will be pleased to have you name a good book on the chemistry of Portland cement."

The American Society of Civil Engineers' committee on a uniform method of testing cements did not recommend a boiling test, but a cold water test for determining the soundness of cements. Concise descriptions of the boiling water and other accelerated tests are given in Spalding's "Hydraulic Cement." We do not know of any comprehensive book in English upon the chemistry of cements.

OPERATING MACHINERY FOR THE NORTH HALSTED STREET DRAWBRIDGE, CHICAGO, ILL.

In our issue of Feb. 21, 1895, we described and illustrated in some detail the Scherzer rolling lift highway bridge across the Chicago River at Van Buren St. in the city of Chicago. This was the first bridge of this type ever constructed, but it was shortly followed by a second bridge built to carry the tracks of the Metropolitan West Side Elevated Ry. across the Chicago River, between Van Buren and Jackson Sts. A third bridge of the same type, but of much longer span, has recently been completed across the Chicago River at North Halsted St. Considerable improvement has been made in each of the two bridges succeeding the first structure, but the last bridge at North Halsted St. is considered to be the most efficient as well as the largest of the three. From information obtained from Mr. W. M. Hughes, M. Am. Soc. C. E., the Chief Engineer, and from Mr. Albert H. Scherzer, the owner of the patents covering the design, we publish in the accompanying cuts such details of the new bridge as are deserving of especial mention.

Superstructure and Foundations.—The general dimensions of the bridge exclusive of the 50-ft. approach span on the south side are: Length of movable portion, 176 ft., divided into two equal parts of 88 ft. each; length of anchor span on the south side, 48 ft. 6 ins., and on the north side, 52 ft. 6 ins., making the total length of the bridge 277 ft. The width of the roadway c. to c. of trusses is 34 ft., and the width of each sidewalk from the center of the truss to the center of the hand rail is 7 ft. 3 ins., making the width over all about 50 ft. The clear opening between the protection piles is 109 ft.; between the faces of the masonry, 121 ft., and between the centers of the bearings, 127 ft. The bridge was designed to carry a uniformly distributed live load of 100 lbs. per sq. ft., or a motor car weighing 18 tons loaded, followed by trailers weighing 15 tons loaded, each having a wheel base of 8 ft. and a length of 32 ft. over all.

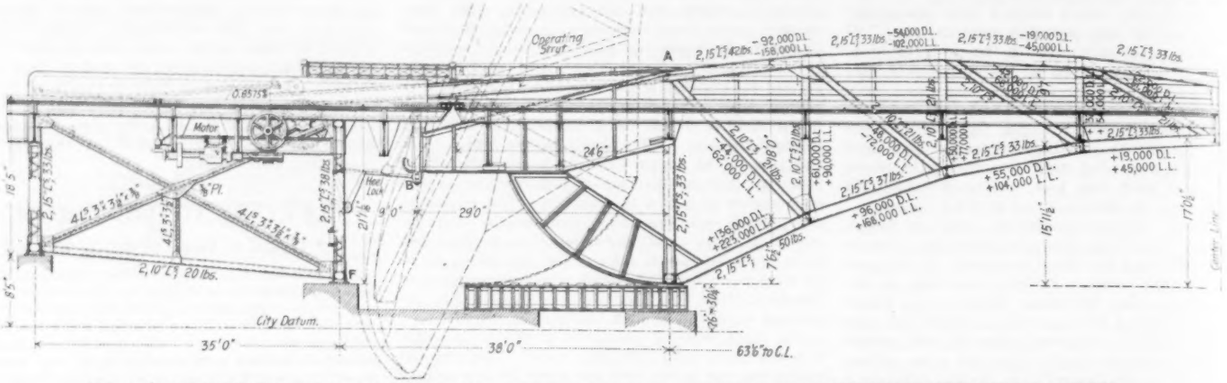


FIG. 1.—HALF ELEVATION OF NORTH HALSTED ST. BRIDGE, CHICAGO, ILL., SHOWING ARRANGEMENT OF OPERATING MACHINERY.

Wm. M. Hughes, M. Am. Soc. C. E., Chief Engineer; L. B. Jackson, M. Am. Soc. C. E., City Engineer, Chicago; The Scherzer Rolling Lift Bridge Co., Contractors.

Fig. 1 shows a general elevation of one-half of the structure, the dotted lines showing the position of the movable portions when open. The segmental girder has bolted to its curved flange a sole plate 26 ins. wide × 2½ ins. thick, with 6 × 12-in. holes spaced 2 ft. apart c. to c. The track upon which this rolls has corresponding lugs which act as a guide to hold the movable part of the bridge in position while it is in motion. The tracks consist of steel castings 26 ins. wide and 2½ ins. thick, bolted to heavy box girders which span an opening of 10 ft. between the piers.

The substructure supporting the movable part and the columns of the anchor span consists of three separate piers on each side of the river, that portion of the piers below datum being made of Portland cement concrete and that part above datum of Bedford limestone. The piers rest upon a pile and timber foundation, the piles being cut off at 17 ft. below city datum, which is about the average stage of water. The piles were driven about 30 ft. into a rather stiff blue clay. Excavation was made to a depth of 2 ft. below the point of cut-off of the piles. Upon the piles 12 × 12-in. oak timbers were placed and secured by drift bolts. Between the heads of the piles and timbers were placed concrete, then two more courses of timber upon which the concrete pier rested. The foundations were put in "dry" by the construction of a coffer dam consisting of piles, timber and clay. Columns F (Fig. 1) are anchored to the masonry by two rods, each 2⅝ ins. square,

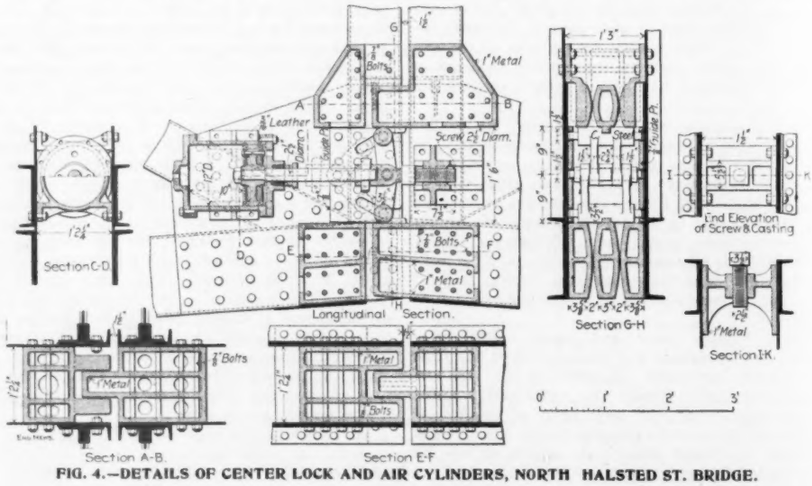


FIG. 4.—DETAILS OF CENTER LOCK AND AIR CYLINDERS, NORTH HALSTED ST. BRIDGE.

running from a pin near the top of the column to a point near the timber grillage, where they are attached to a system of I-beams.

Operating Machinery and Electrical Equipment.—The bridge is operated by an electric motor on each side of the river, the requirements of the specifications being: "The motor shall be of the railway type, series-wound single-reduction multipolar, with four salient poles, waterproof, with steel frame, and iron clad armature, to have a capacity of 50-HP. and to be capable of carrying an over load of 33⅓% for half an hour without injurious heating, and to have an armature speed of not less than 600 R. P. M. when 50 HP. is being delivered by the motor at 500 volts." The reduction from the armature of the motor to the main driving wheel, which engages in the rack of the operating strut is 550 to 1. By the use of worm gearing the machinery was very much simplified, not only a large amount of gearing being dispensed with, but also the necessary supports to carry the same, all machinery being suspended from the main girders and floor beams of the anchor span.

On the motor shaft, which runs longitudinally with the bridge (Fig. 2), is placed a beveled gear for hand power, which connects with a vertical shaft running up to the floor level, and also the brake wheel and worm. The latter engages in the worm wheel, which is placed on a cross shaft. On each end of this shaft and in line with the

center of the girders of the anchor span is a pinion which meshes into the main driving wheel and this in turn engages in the rack of the operating strut, which is connected by pin to the movable part of the bridge at A, Fig. 1. The bearings of the motor shaft are babbited, but all the other bearings are phosphor-bronze made of 88 parts copper and 12 parts of phosphorized tin, the latter containing 5% of phosphorus.

The worm is of the Hindley type as made by the Allen-Clem Elevator Co., of Philadelphia, Pa., the threads being cut on lines radial to the center of the worm wheel. In the use of the worm it was found there was little or no necessity for a brake as the machinery holds the bridge in any position in which it may be placed. The worm wheel is a steel casting and the worm is of phosphor-bronze, the center diameter being 16 ins. and the end diameter 18 ins., the threads being cut to 3-in. pitch. The maximum thrust on the worm is about 22,000 lbs., and is taken up by the steel castings, which are bolted to the lower flanges of the girders which support the worm wheel. In these castings, which also act as bearings for the worm shaft is a phosphor-bronze bushing, between this and the ends of the worm are three loose collars, the one next to the worm being cast-iron, the one next to the thrust block being forged steel, and the one between these being made of phosphor-bronze in two pieces for easy removal in case of wear. All bearing surfaces have proper radial grooves for the purpose of oiling.

The current is furnished by the street railway company, which has an electric line crossing the bridge. To open the bridge an average of about 40 HP. is required on each side of the river, and about the same is required for closing. The maximum required is about 55 HP., which occurs for a few seconds only at or near the end of the operation of opening or closing. The time required for opening and closing is from 40 to 50 seconds each way. The center locks (Fig. 4), heel locks (Fig. 5), signal gates and brakes (Fig. 6), are worked by compressed air, there being placed in the operator's house on each side of the river an air compressor operated by an electric motor. These are so arranged as to be automatic, the current being cut out at 60-lbs. pressure in the receiver. The receivers on each side of the river are connected by a 1-in. lead pipe passing beneath the river, and each compressor is of sufficient capacity to operate the locks, signals, etc., on both sides of the river.

The only necessity for gates in a bridge of this type is to stop the traffic when the bridge is ready to be opened. Each gate is operated independent of the other, so that those of the roadway on the right can be closed first, thus gaining time by stopping the traffic approaching the bridge and allowing that on the other roadway to pass off, while the signals are being given and the center locks drawn.

The work on the substructure was commenced Jan. 22, 1896, and the bridge was opened to traffic Jan. 20, 1897. Wilson & Jackson, of Chicago, Ill., were the contractors for the substructure; the King Bridge Co., of Cleveland, O., for the superstructure, and the Vulcan Iron Works, of Chicago, Ill., for the machinery and electrical equipment. All work was done in a very satisfactory manner. The plans for the superstruture were prepared by Mr. W. M. Hughes, M. Am. Soc. C. E., of Chicago, acting as Consulting Engineer for the city, subject to the approval of Mr. L. B. Jackson, City Engineer. Mr. Hughes also had general supervision of the the work during construction. The cost of the work in round numbers was:

Substructure	$34,500
Superstructure	55,400
Machinery (including operating struts)	13,560
Electrical equipment	5,400
Engineering, Inspection, temporary foot bridge and other incidental expenses	14,740
Total	$123,600

The weight of the superstructure including the 50-ft. approach span was about 820 tons, 300 tons of which was counterweight. The weight of the machinery was about 70 tons.

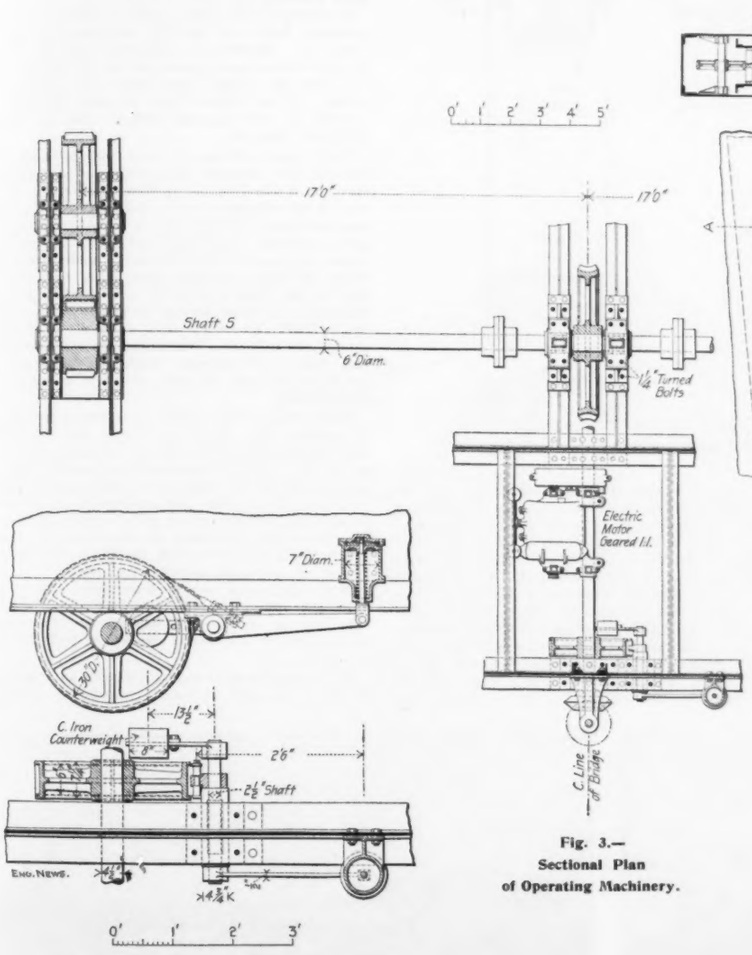


Fig. 3.—Sectional Plan of Operating Machinery.

Fig. 6. Details of Brake Wheels and Levers.

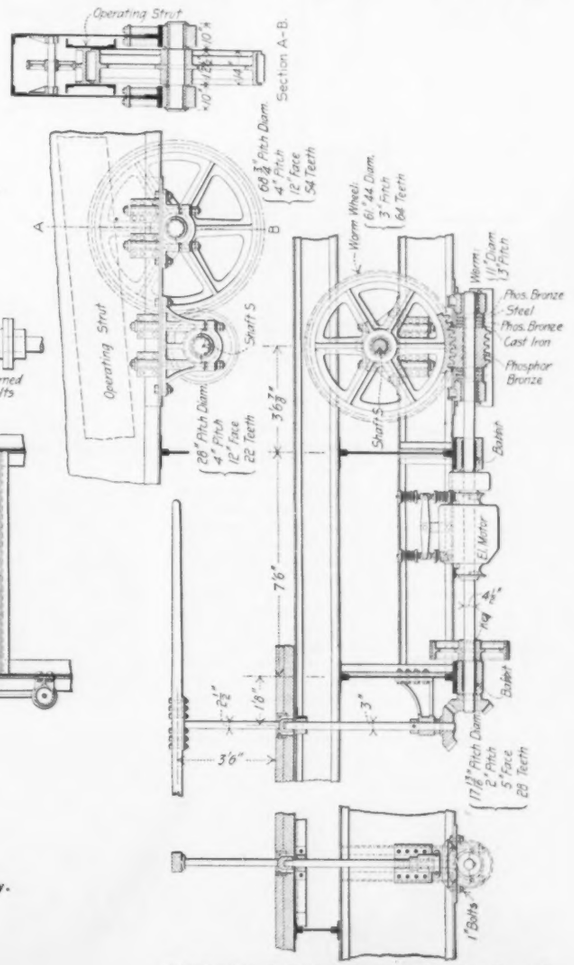


Fig. 2.—Longitudinal Section Showing Location and Connections of Main Motor Shaft.

EXPERT TESTIMONY.*

By Prof Wm. P. Mason, M. Am. Soc. C. E.†

It will be remembered that a would-be facetious barrister once remarked that prevaricators might be properly arranged in an ascending series, to wit: ordinary fibbers, liars and experts; an arrangement which I fear meets with the approval of many members of the bench and bar today. The cause for such harsh classification is not so very far to seek. It is based upon ignorance on the part of the bar, and at times upon what is worse than ignorance on the side of the "expert." With the culpable acts of the pseudo-scientist we cannot waste our time. That he merits prompt condemnation is axiomatic; but a word is wanted touching upon what may be termed the ignorance of the court.

"When I take my place upon the witness stand," said a prominent toxicologist once to me, "I can never predict in what shape I shall be upon leaving it," a feeling with which most of us can, I fancy, sympathize pretty keenly.

*Extracts from Vice-Presidential Address before the Section of Chemistry, American Association for the Advancement of Science, Detroit Meeting.

†Professor of Chemistry, Rensselear Polytechnic Institute, Troy, N. Y.

Is it that we fear exposure of the weak points in our professional armor? Do we dread to say in public "I do not know?" Hardly that, I take it. We are now possessed of so very little of that which one day may be known, that no true scientist hesitates for an instant to plead legitimate ignorance. What really troubles us upon cross-examination is that the court does not speak our language, a language often quite difficult of direct translation; that it is but rarely schooled in the principles of our science; and that, in consequence, it frequently insists upon categorical answers to the most impossible kind of questions.

The hypothetical questions showered upon the expert witness are sometimes veritable curiosities, so peculiar are they in their monstrosity. Who among us but has felt that the layman, who has simply to testify to observed facts, has an easy time of it indeed, when compared with him from whom there is expected an opinion under oath?

All scientific men are willing and anxious to have their work scrutinized carefully by their peers; but, to be exposed to the one-sided criticism frequently encountered at the bar is quite another matter; for it must be remembered that after the adverse counsel has opened up what appears to be a glaring inconsistency in the testimony, the re-direct examination may utterly fail to repair the breach, because of a lack of familiarity with a technical subject on the part of the friendly attorney.

This leaves the witness in the unenviable position of disagreeing with the general drift of his own testimony, while it deprives him of suitable means of insisting upon its revision and correction.

According to the writer's view, there is but one way to escape such dilemma, and that is by direct and immediate appeal to the judge; urging that the oath taken called for a statement of the whole truth, and not the misleading portion already elicited.

Although the expert should earnestly strive to have what he has to say presented in the best form, he must remember that to secure clearness, particularly before a jury, technicalities should be reduced to a minimum. To a degree they are unavoidable, but let them be as few as possible. Illustrations should be homely and apt; capable of easy grasp by the jury's minds, and if possible taken from scenes familiar to the jury in their daily lives.

It is an unfortunate fact that the expert must be prepared to encounter in the court-room not only unfamiliarity with his specialty, but also deep-rooted prejudices and popular notions hoary with age and not to be lightly removed from the mind by the words of a single witness. As President Jordan has well said: "There is no nonsense so unscientific that men called educated will not accept it as science," and, let me add, they will calmly attempt to shove the burden of proof upon the scientific man who is opposed to their views. Sanitary experts, in particular, run up against all sorts of popular superstitions and are inveighed against as "professors" by those who consider themselves the "practical" workers of the time; and, let it be noted, the burden of proof is uniformly laid upon these "professors'" shoulders, while the most astounding and occult statements made by the "practical" man may be received without verification.

One source of trouble, which perhaps is peculiar to the water expert, lies in the impossibility of utilizing analytical results such as were made many years ago.

Those who are not chemists fail to grasp the fact that the examination of water may not be looked upon from the same point of view as the analysis of an iron ore. The statement that water analysis is but of recent birth, and that it is yet in its infancy, is hard for them to appreciate holding, as they naturally do, that what was true twenty years ago must be true to-day, if science does not go.

A pit into which many an expert witness falls is prepared for him by insidious questions leading him to venture an opinion upon matters outside of his specialty. It is a fatal error to attempt to know too much. Terse, clear answers, well within the narrow path leading to the point in question, are the only safe ones; and when the line of inquiry crosses into regions where the witness feels himself not truly an expert, his proper course is to refuse to testify outside of the boundaries of his legitimate province.

Unfortunately the expert is as often invited to take these collateral flights by the side employing him as by the opposition. Affidavits in submitted cases are commonly written by the lawyers and not by the expert, although they are, of course, based upon his reports. In the strength of his desire to win the case, the lawyer often prepares a much stronger affidavit than his witness is willing to swear to.

Every expert witness, especially in his early cases, is sure to have adverse authorities quoted against him; therefore it behooves him to be so familiar with the literature of his subject as to be capable of pointing out that such and such a writer is not up to date, or that such and such a passage, if quoted in full, would not bear the adverse construction that its partial presentation carries. When the expert reaches a position of such prominence that he can state a thing to be so because he says it, irrespective of whatever may be written on the subject to the contrary, his course then is greatly simplified; but long before he attains that altitude he will have put himself upon record in many cases, and happy for him if the record so made be such as cannot be quoted to his disadvantage.

Before the case is brought to a final hearing, it may be apparent that experiments before the court are possible and they may be demanded by the counsel in charge of the case. If such experiments be striking, easy of execution, and not too long, by all means make them.

Practical illustrations, particularly such as involve some fundamental principle, have great weight with the court; but these illustrations must not be such as would turn the court-room into a temporary laboratory and involve the loss of much time in vexatious waitings.

Such experiments as are determined upon should be thoroughly rehearsed beforehand, no matter how simple they may be; for, of all failures, the court-room experiment which declines to "go-off" is perhaps the most dismal.

This brings to mind a kindred topic upon which there should be a word of caution; laboratory experiments,

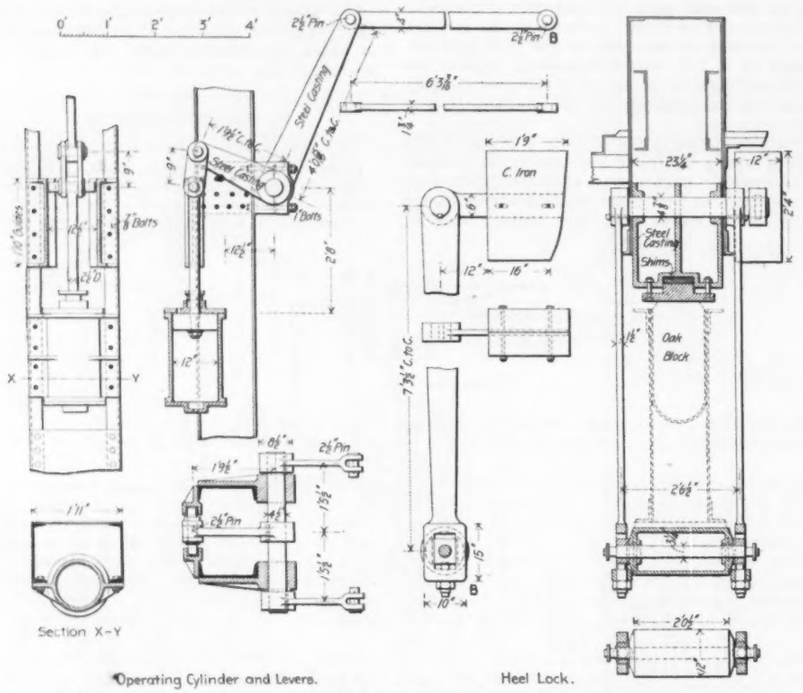


FIG. 8.—DETAILS OF HEEL LOCKS AND AIR CYLINDERS, NORTH HALSTED ST. BRIDGE.

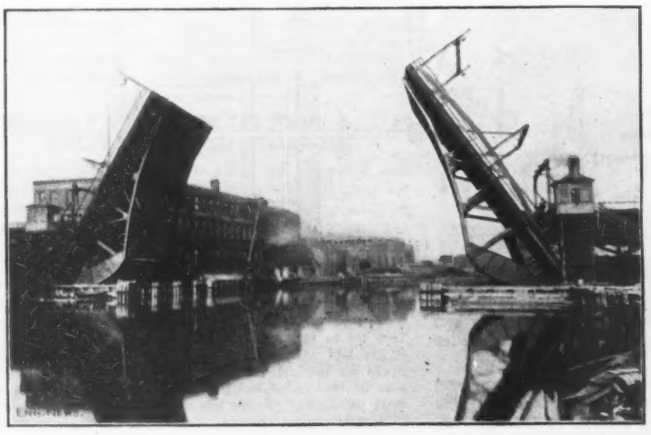


Fig. 7.—Bridge Open.

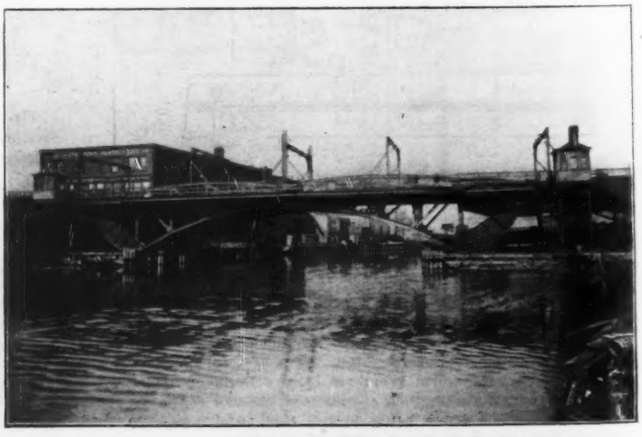
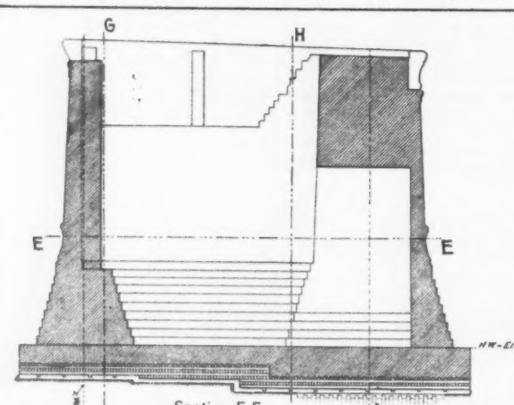
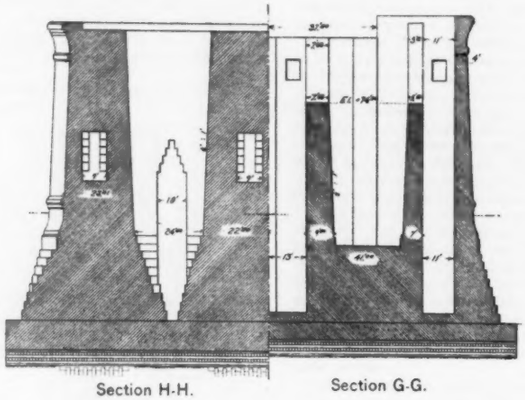


Fig. 8 —Bridge Closed

FIGS. 7 AND 8.—SCHERZER ROLLING LIFT BRIDGE ACROSS THE CHICAGO RIVER AT NORTH HALSTED ST., CHICAGO, ILL.



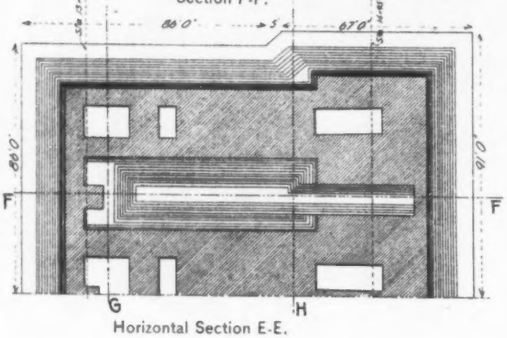
Section F-F.



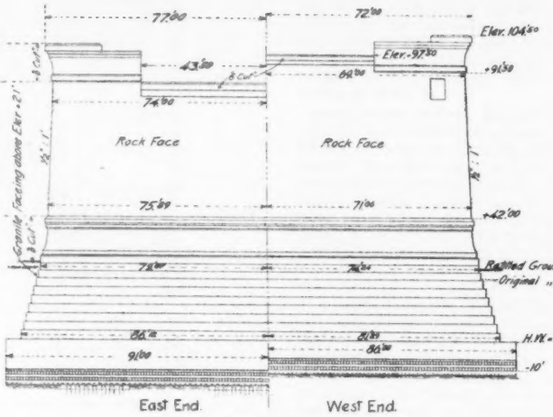
Section H-H.

Section G-G.

Half Pla



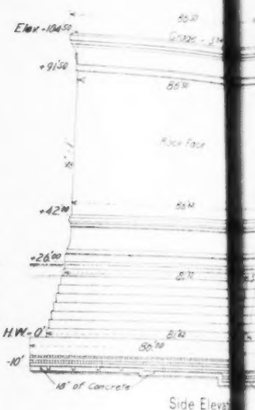
Horizontal Section E-E.



East End.

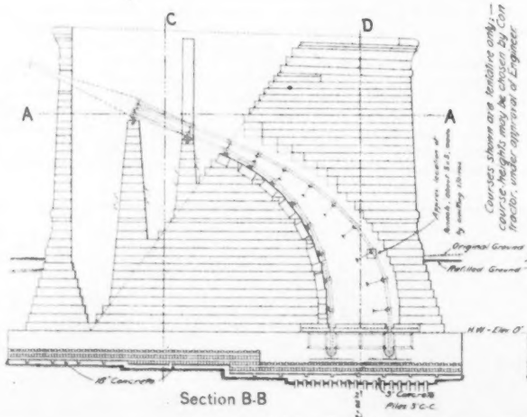
West End.

End Elevation.

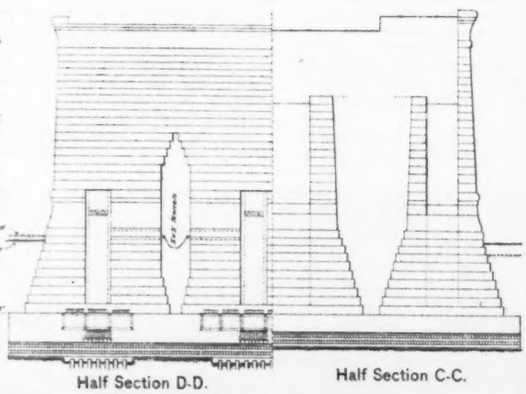


Side Eleva

ELEVATIONS AND SECTIONS, SHOWING MASONRY CONSTRUCTION.

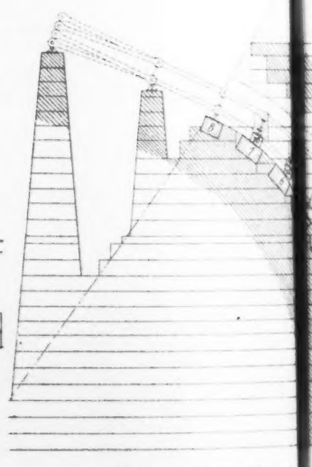


Section B-B

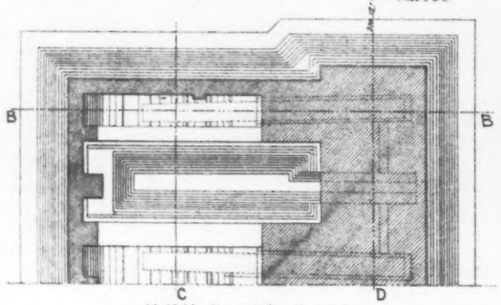


Half Section D-D.

Half Section C-C.



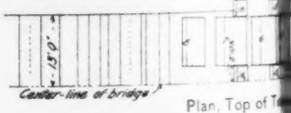
Vertical Section through Tunne



Half Horizontal Section A-A.

Work to be done.- Quantities approximate only.:-

Earth Excavation (if sheeted vertically on all sides)		34000 Cu Yds.
Refilling :- to Elev. +25 after settlement, for 10 from Ground-line of masonry		
Piles :- spaced 3 C.-C. as per Plan – Total Number		432 Piles.
Concrete :- below Timber platform		1710 Cu Yds.
between Timber platform and Elev. 0'	8740 "	
replacing masonry above Deck-beams	435 "	10885 Cu Yds.
Timber Platform :- Yellow-pine Timber in work		120000 Cu Ft.
1¼" iron Drift-bolts	"	67 Tons.
Stone Masonry		44597 Cu Yds.
Anchorage Metal :- Chains	875 Tons.	
Girders	474 "	
Castings	203 "	1553 Tons.



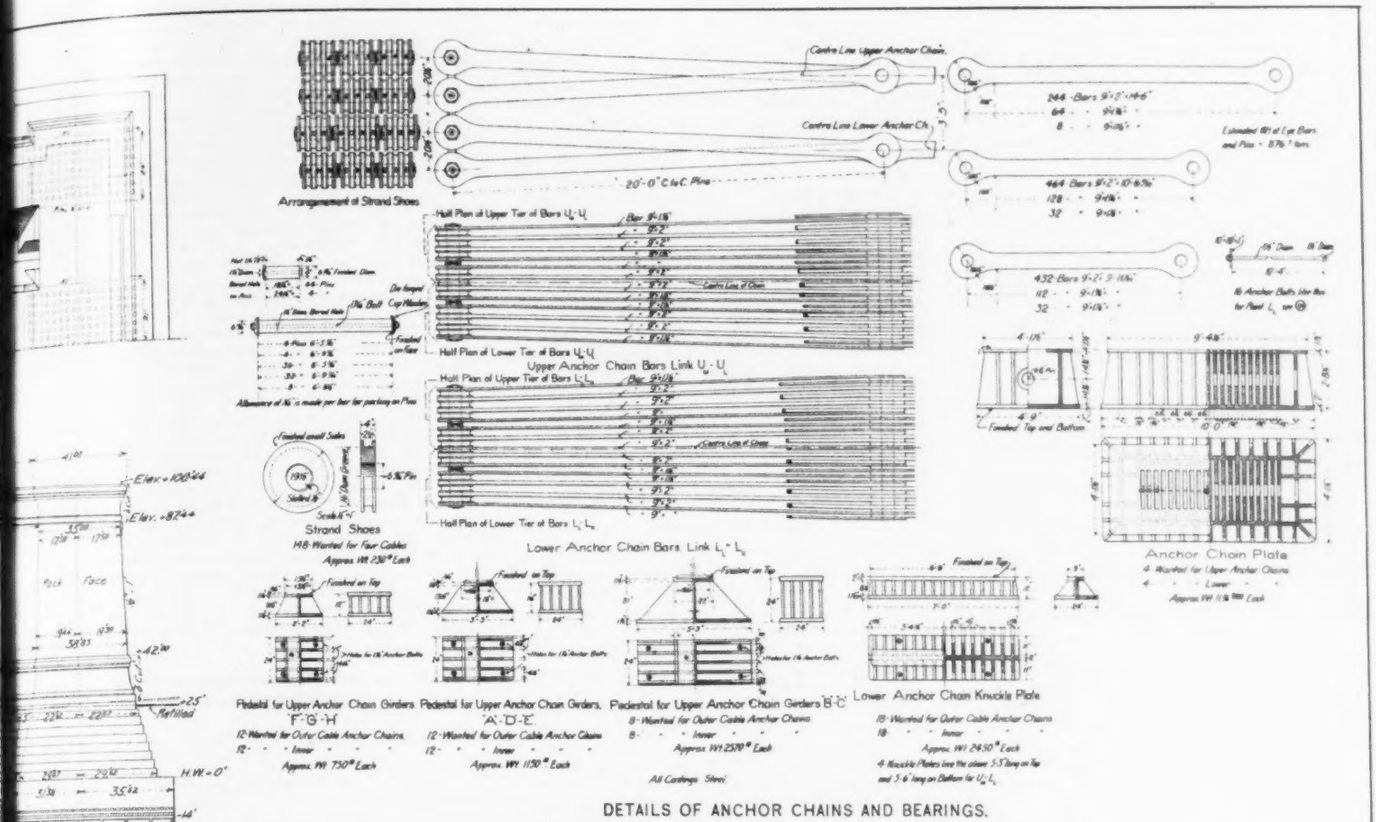
Plan, Top of T

ANCHOR CHAIN TUNNELS AND SUPPORTS.

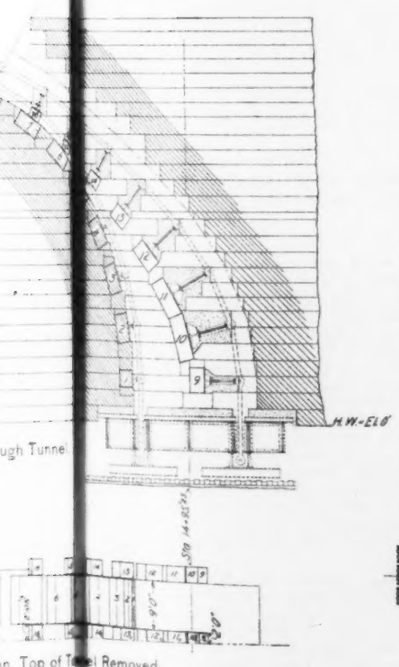
ARRANGEMENT OF ANCHOR

BROOKLYN ANCHORAGE OF T

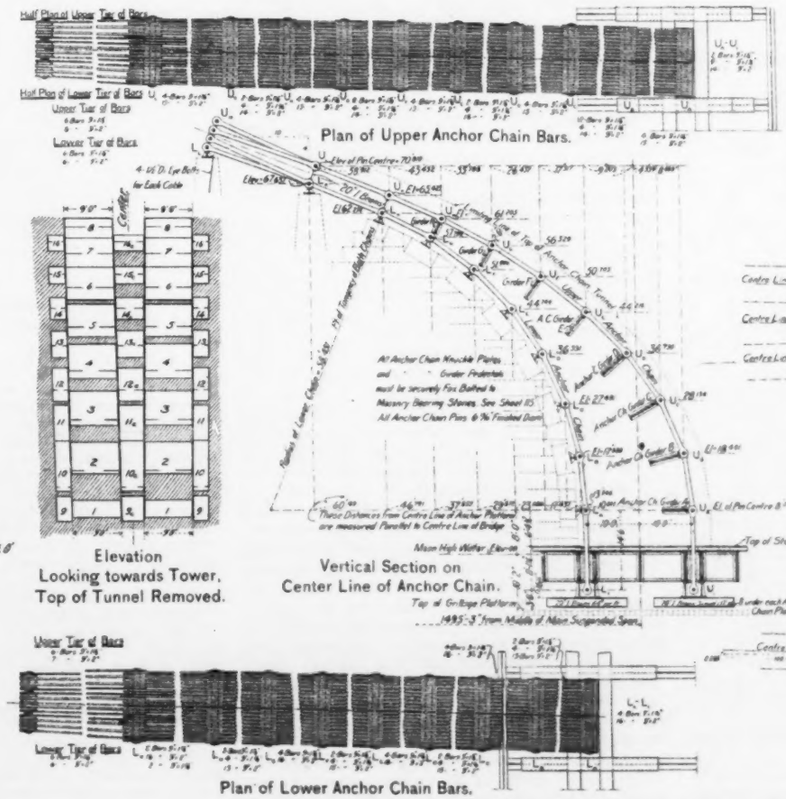
L. L. Buck, M. Am. S


Arrangement of Strand Shoes
Centre Line Upper Anchor Chain
Centre Line Lower Anchor Ch
20'-0" C to C Pins
Half Plan of Upper Tier of Bars U₁-U₁
Half Plan of Lower Tier of Bars U₁-U₁
Upper Anchor Chain Bars Link U₁-U₁
Half Plan of Upper Tier of Bars L₁-L₁
Half Plan of Lower Tier of Bars L₁-L₁
Lower Anchor Chain Bars Link L₁-L₁
Strand Shoes
Anchor Chain Plate
Pedestal for Upper Anchor Chain Girders F-G-H
Pedestal for Upper Anchor Chain Girders A-D-E
Pedestal for Upper Anchor Chain Girders B-C
Lower Anchor Chain Knuckle Plate
All Castings Steel.

DETAILS OF ANCHOR CHAINS AND BEARINGS.



OF ANCHOR CHAIN BEARING BLOCKS.



GENERAL ARRANGEMENT OF ANCHORAGE CHAINS AND GIRDERS.

GE OF THE NEW EAST RIVER BRIDGE.

. Am. Soc. C. E., Chief Engineer.

CHAS. HART & SONS, LITH., 35 VESEY ST., N. Y.

conditions will at times creep into one's calculations, and how hard it is even to recognize their presence.

When preparing his case for presentation, the expert often errs in not dwelling more largely upon certain points because he thinks them already old and well known. To him they may be old, but to the public they may be of the newest. Not only is the public unequally posted with the specialist but what it once knew upon the subject may have been forgotten: It is well, therefore, to insert, in a special report, matters that would be properly omitted from a paper prepared for a professional audience.

What can be said upon this question of the disagreement of expert witnesses? First, it must be noted, they are far from being the only class of people who fail to agree, and that too on very important subjects. Do my hearers think it would be a very difficult task to find a small army of men who would testify very variously and very positively upon questions of politics or religion? Would it be hard to find "good men and true" who would give under oath greatly differing opinions concerning the propriety of instituting free trade or establishing an inheritance tax? Experts are subject to the same errors of judgment as befall the rest of professional humanity, and, when their opinions clash, they are entitled to the same respect that we grant to the members of the bench when they hand down the decision of a divided court.

One fruitful opportunity for disagreement always arises when questions are brought into court touching upon matters newly discovered and apart from the well-beaten path of common professional knowledge. Doubt is often left upon the minds of those seeking the light, even when the testimony is given by the specialist who originally developed the new point in question, for one cannot be expected to be thoroughly educated in that which he has himself but recently discovered.

A recent and somewhat amusing instance arose from an attempt to introduce the rather new conception of "degeneracy" into a murder trial. The defence sought to

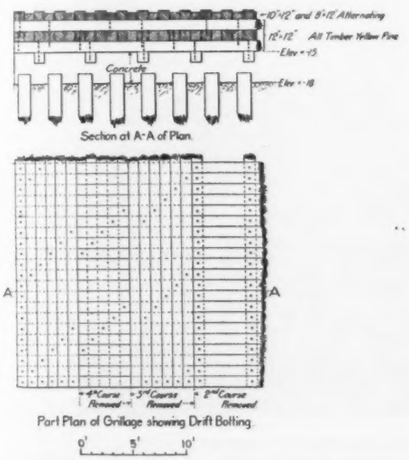


Fig. 1.—Plan and Section Showing Construction of Timber Grillage for Anchorage Foundations of New East River Bridge.

show that the prisoner was a "degenerate" and offered expert testimony as to the meaning of the term and as to the signs whereby such a condition was to be recognized; whereupon the prosecution called attention to the fact that the defendant's experts themselves exhibited every one of the signs in question.

Having said all that he was to say, and having stated it to the best advantage, should the expert depend upon the stenographer's so recording it as to allow of its being used in future without correction? Decidedly not. The average stenographer is unfamiliar with technical terms, especially such as are chemical, and the witness who fails to supervise the minutes may find out later that he was sworn to a most remarkable array of "facts." The writer once discovered that he had recommended, as a very efficient method of purifying a city water, the filtering of the entire supply "through a layer of black mud."

Not to take your time further, let us summarize what has thus been briefly said: The expert witness should be absolutely truthful, of course; that is assumed, but beyond that he should be clear and terse in his statements, homely and apt in his illustrations, incapable of being led beyond the field in which he is truly an expert, and as fearless of legitimate ignorance as he is fearful of illegitimate knowledge.

Mounting the witness-stand with these principles as his guide, he may be assured of stepping down again at the close of his testimony with credit to himself and to the profession he has chosen.

THE ANCHORAGES FOR THE NEW EAST RIVER BRIDGE.

(With two-page engraving.)

The drawings on our two-page engraving this week shows the general details of the Brooklyn anchorage for the new East River Bridge, and the New York anchorage will be the same in all important respects, with the few exceptions which will be noted further on. This bridge will cross the East River about 1½ miles above the present New York and Brooklyn Bridge, with a suspension span 1,600 ft. long, between centers of towers, and is 7,200 ft. long between terminals. The suspension cables will be supported by two masonry and steel towers 335 ft. high, and the anchorages, which are illustrated here. In our issue of July 30, 1896, we illustrated the general design of the bridge, and in the succeeding issue of May 27, 1897, the timber caisson foundations for the main towers were illustrated and described in detail. The illustrations of the Brooklyn anchorage which we publish this week are reproduced direct from the engravings accompanying the specifications, and from the body of the same specifications we select the following information, as being of chief interest in connection with the drawings. Proposals for constructing the anchorages, complete, as shown, will be received Sept. 22, 1897.

Brooklyn Anchorage.

Foundation Bed and Piles.—The site of the Brooklyn anchorage of the new East River Bridge occupies the larger part of the block bounded by Kent Ave., Wythe Ave., South Fifth St. and South Sixth St., in the city of Brooklyn. From an area of about 135×285 ft., the buildings will be removed, becoming the property of the contractors, and the masonry or anchorage proper will cover an area of about 135 × 150 ft. The outline of the anchorage in plan is rectangular. It is widened at the rear by offsets, so as to give greater mass over the outer anchor girders. In its general plan the anchorage conforms closely to the plan of the anchorages for the present Brooklyn Bridge, but it covers a somewhat greater area, being as stated roughly 135 × 150 ft., as compared with 129 × 110 ft. for the older bridge.

To prepare the foundation for the anchorage an excavation will be made somewhat larger than the full size of the anchorage, with its sides supported by sheet piling. The depth of the excavation is shown by the drawings, and it may be stated here that wherever dimensions are given by the drawings, which we publish, they have not been repeated in the text.

When the excavation is completed yellow pine piles, not less than 10 ins. in diameter at the tips and 14 ins. in diameter at the point of cut-off, will be driven by a 4,000-lb. hammer falling 35 ft., until the penetration from the blow is not more than 2 ins. To test the condition of the soil and to obviate any chance of the pile having struck a thin hard shell, overlying softer material, the specifications require that five additional blows shall be given to the pile, after the resistance described above has been reached. When driven the piles will be cut off level 1 ft. above the bottom of the excavation, and the space between and around their heads will be filled with concrete. This concrete will be carried above the tops of the piles to the bottom of the solid timber work, and will have 12 × 12-in. timbers embedded in it, as shown by the drawings.

Timber Platform.—On the concrete bed, constructed as just described, will be built a timber platform, to carry the masonry. This platform will be of yellow pine timber, constructed as shown by Fig. 1 in the text. This drawing shows plainly the manner of breaking joints and the system of drift bolting the timbers. Each timber of the first three courses will be dressed to exact vertical dimensions, and, if necessary, to give them a uniform bearing on the concrete, the first course timber will be laid in a bed of cement mortar. All the drift bolts will be blunt pointed 1⅛ ins. in diameter, driven into 1-in. holes; those for the first and second courses will be 22 ins. long, those for the third course, 30 ins. long, and those for the fourth course, 26 ins. and 28 ins. long.

Concrete Masonry.—From the top of the timber platform to high-water level the anchorage masonry will be of concrete, with the proper chambers for the anchor girders built as shown by the drawings. To make these girder chambers water tight they will be lined with asphalt. Before beginning the stone masonry the anchor girders and the first links of the anchor chains will be placed.

The approximate quantities of materials in the work previously described are given by the specifications as follows:

Earth excavation, if sheeted vertically on all sides, cu. yds	34,000
Total number of piles spaced 3 ft. c. to c	432
Concrete below platform, cu. yds	1,710
Concrete between platform and high water, cu. yds.	8,740
Concrete replacing stone, cu. yds	435
Yellow pine platform timber, cu. ft.	120,000
Drift bolts, tons	67

Stone Masonry.—On top of the concrete masonry will begin the stone masonry which, in general form with all the details of the supports and tunnels for the anchor chains, is shown by the drawings on the double-page engraving. Altogether there are 44,597 cu. yds. of this masonry. It will consist of a facing, base, cornice, coping and knuckle stones, with the necessary backing. Fig. 2 shows the details of the base cornice and coping masonry clearly, with the exception of the clamps and dowels. This is all six-cut dressed stone work. Fig. 3 shows one of the cast-steel

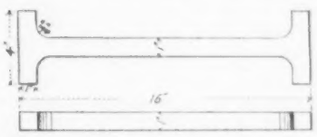


Fig. 3.—Details of Clamps for Joints in Masonry Course Below Coping.

clamps. Two of these clamps placed horizontally are used to clamp each joint of the facing in the course next to the coping. The face stones of the coping itself are doweled to the stones below, with round steel dowels 1¼ ins. in diameter, extending into the stone 6 ins. at top and bottom.

Between the cornice and base, and for 4 ft. below the base, which is just above the ground, the facing will be rock-faced granite laid in courses, from 2 ft. to 2½ ft. thick, with ½-in. bed joints throughout, and ½-in. vertical joints for a distance

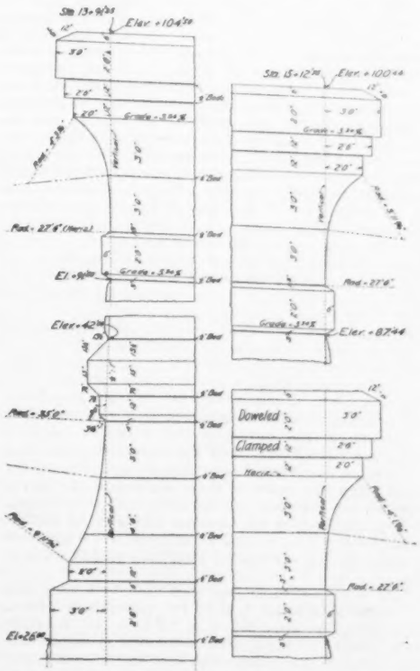


Fig. 2.—Details of Base and Cornice Masonry and Moldings.

of 1 ft. back from the face. Every second or third stone in the face of each course will be a header, with a 3-ft. face, and a length of three times its height. In other respects the face-stone masonry is ordinary first-class coursed masonry. The backing will consist of stones of large size, roughly rectangular and oblong in shape, of a width not

less than their height, and so placed as to bond the masonry throughout. All masonry will be laid in Portland cement mortar, made with the proportions of 375 lb. of cement to 8½ cu. ft. of sand. No retempered mortar will be used. The composition of the concrete used in various parts of the work will consist of six parts broken stone to three parts mortar.

Anchors.—To contain the anchor chains there will be four tunnels in the masonry, arranged as shown by the drawings, two close together, near the centre of the anchorage, and one on each side of those near the sides of the anchorage. Each anchor chain will consist of two separate chains of eye-bars, connected to a single anchor, made up of plate girders, arranged as shown by the drawings. The bottom chain is supported at each joint along its convex side on cast-steel shoes, fastened to the granite-bearing stones, numbered from 1 to 8. These stones will be rectangular and will extend transversely across the tunnel a distance of 9 ft., in not more than three parts. Stones 2 to 7, inclusive, will be 5½ ft. wide; stone 1, 3 ft. wide; stone 2, 4 ft. wide, and all stones will be 3 ft. thick. The top chain is supported at its joints by plate girders, spanning the tunnel transversely, with their ends carried by cast-steel shoes, fastened to the granite-bearing blocks, numbered from 9 to 16, inclusive. Except the anchor girders and the girders supporting the chain, all parts of the metal work of the anchorages are shown in detail by the drawings. The girders themselves need no description, beyond saying that they are all open hearth steel-plate girders, varying in depth and section to suit the strain brought upon them.

Materials.—The best idea of the character and quality of the more important materials used can be given by quoting parts of the specifications:

Stone for Concrete.—Stone for concrete shall be clean, hard, angular, machine-broken limestone or trap rock, of not more than 2 ins. in largest dimension, mixed with smaller stone of the same kind not less than ¼-in. in least dimension.

Portland Cement.—The cement for the masonry and the concrete shall be an approved brand of Portland cement. Briquettes of neat cement, exposed in air for 24 hours and then immersed in water for six days, must have a tensile strength of at least 350 lbs. per sq. in. Briquettes mixed of one part cement to two parts dry sand by weight, exposed in air for 24 hours and then immersed in water six days, shall have a tensile strength of at least 150 lbs. per sq. in. Pats of neat cement set in air and then immersed in water shall show no checks or cracks. All Portland cement must be fresh and finely ground. At least 90% must pass through a sieve of 10,000 meshes per sq. in. The test for tensile strength will not be considered final or conclusive in determining the character of any cement or as compelling the acceptance of a cement otherwise objectionable in the opinion of the engineer. Uniformity in quality is desired. All cement must be carefully handled and protected from the weather and moisture at all times, and all cement rejected must be promptly removed from the site of the work.

Sand.—All sand for mortar must be clean, sharp and free from mica. For masonry it must be passed through screens having openings ½-in. square. For concrete it must be free from stones and large pebbles.

Steel.—All steel will be open hearth acid steel, but no steel shall be made at any works which have not been in successful operation for at least one year. In all steel the amount of silicon shall be less than 0.1%, of phosphorus less than 0.05%, of sulphur less than 0.03%, and of manganese less than 0.5%. Less than 0.3% of manganese will be preferred. The amount of carbon shall be between 0.15% and 0.25%. Steel shall not be melted below from 0.12% of carbon. The manufacturer shall have an analysis of every melt made by a chemist satisfactory to the engineer, and two copies thereof certified by such chemist shall be delivered to the inspector appointed by the engineer. Every facility shall be afforded to the inspector to verify the requirements for every melt of each grade of steel.

Tests of Steel.—For testing, steel shall be divided into six grades as follows: I. Steel for angles and plates. II. Steel for eye-bars. III. Steel for pins. IV. Steel for rolled beams. V. Rivet steel. 1-in. rods as rolled. VI. Steel castings. All specimens 0.5 sq. in. in section, cut from the shapes, shall meet the following requirements respectively:

Grade.	I.	II.	III.	IV.	V.	VI.
Max. ult. strength, lbs. per sq. in.	68,000	72,000	....	68,000	56,000	....
Min. ult. strength, lbs. per sq. in.	60,000	64,000	68,000	60,000	47,000	60,000
Min. elastic limit, lbs. per sq. in.	33,000	35,000	35,000	32,000	30,000	....
Min. P. C. elong. in 8 ins	20	20	17	20	25	....
Min. P. C. elong. in 2 ins	....	....	....	....	....	20

Grade II., when tested in full size bars, shall have an ultimate strength of at least 60,000 lbs. per sq. in., an elastic limit of at least 35,000 lbs. per sq. in., and an elongation of at least 15% of the original length of the parallel portion of the bar for bars of from 9 to 12 ft. long. Specimens of Grades I., II. and IV. when bent cold 180° about a diameter equal to the thickness of the specimen shall show no crack on the convex side. Specimens of Grade III. when bent cold 180° about a diameter 1½ times their thickness shall show no crack on the convex side. Specimens of Grade V. when bent cold to closing upon themselves shall show no crack. A rod ¾-in. in diameter, nicked one-quarter the way through, shall bend cold to closing without cracking with the nick on the convex side. All rolled shapes shall be rolled from ingots having a thickness at least 16 times that of the shape to be rolled therefrom. All rolled and hammered shapes shall be entirely free from piping, checks, cracks or other imperfections, and shall have smooth finished edges and surfaces. Rivets cut out of work into which they have been driven shall be tough and show a silky texture without crystaline appearance. Specimens of Grade IV. shall be cut from flanges midway between one edge and the web. Grade VI. All castings shall be sound and as free from blow-holes as possible. No casting showing blow-holes over ¼-in. in diameter on the surface will be accepted. All steel fractures shall show a fine silky texture of a bluish grey or dove color, free from black or brilliant specks. Rigid tests will be made for red shortness.

The specifications for workmanship are such as are usual with first-class steel structural work of an important character.

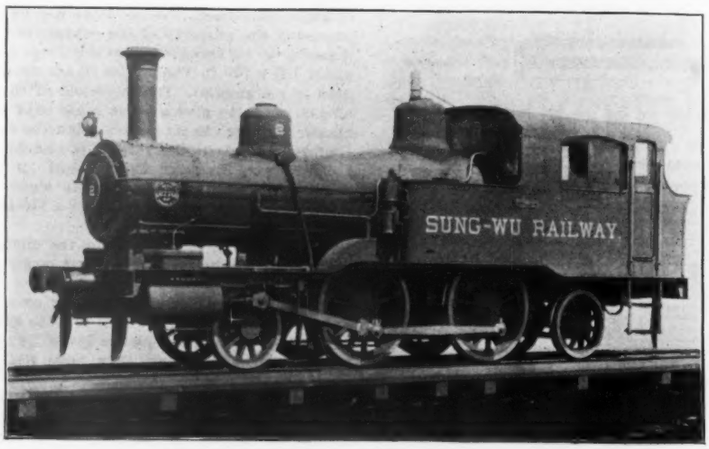
New York Anchorage.

The area occupied by the masonry of the New York anchorage is 151 ft. 9 ins. × 168 ft. 6 ins., and in outline the plan of the anchorage is the same as that of the Brooklyn anchorage. The similarity is also true for the general construction of the foundations, platform and masonry. Borings made on the foundation site show the bed rock to be from 60 ft. to 95 ft. below the level of high water, which is about 6 ft. below the surface of the ground. The material penetrated after the made ground is passed is silt, then clay, and then sand of various grades. The slope of the bed rock is toward the river. The specifications for constructing this anchorage are exactly the same as for the Brooklyn anchorage. Proposals for the construction of this anchorage will also be received on Sept. 22, 1897.

The engineers of the new East River Bridge are Mr. L. L. Buck, M. Am. Soc. C. E., Chief Engineer, and Mr. O. F. Nichols, M. Am. Soc. C. E., Principal Assistant Engineer.

PASSENGER TANK LOCOMOTIVE; SUNG-WU RAILWAY, CHINA.

The Brooks Locomotive Works, of Dunkirk, N. Y., have recently built three tank locomotives for passenger service on the Sung-Wu Line (Sung-Wu Railway Co.) of the Imperial Chinese Railways, and we are indebted to the builders for photographs and dimensions of these engines. As will be seen by the accompanying cut, there are four coupled wheels and single leading and trailing pairs of wheels, the axles of these wheels being carried in sliding boxes. The boiler is of the wagon-top type with sand-box mounted on the barrel and dome mounted on the wagon-top. The smokebox is short and the smokestack is cylindrical. The tanks are on either side of the boiler but do not extend very far forward, while the coal bunker is at the extreme end of the frames. The cab is entirely of steel plate, with large window openings of the pattern commonly used by the builders, and is fitted with doors and sliding sashes. The bumper beam is composed of a channel iron to which are attached the spring buffers and an automatic coupler head. No pilot or cow-catcher is used, but the vertical iron knives attached to the front and rear buffer beams are intended to knock off any obstruction on the track, and these are among some of the English-looking appurtenances of the engine. The connecting rods and coupling rods are of rectangular section and the latter are fish-bellied in shape, with solid ends bushed for the crank pins. The valve gear is of the shifting link type graduated to cut off equally at all points of the stroke. Another English-looking feature of the engine is the small lantern on the top of the smokebox, which is evidently intended merely as a marker and in no way serves the purpose of the American headlight. From this and the absence of a cow-catcher, it may be inferred that the line is built on English principles and strongly fenced in from the first construction. The firebox is of annealed copper plates, as in European practice, but the tubes are of charcoal iron. The engine is fitted with the Westinghouse automatic train brake, the brake pump being mounted in front of one of the tanks. It is also fitted with the Brooks Locomotive Works driving-wheel brake, operated by air and by a hand-wheel and screw in the cab. The engine is for a track of standard gage, and will burn bituminous coal for fuel. It was apparently designed on the metric system of measurement and the important figures of the cylinder dimensions and diameter of driving wheels are given by the builders in this measurement. The following is a list of the general dimensions, given in our standard form:



PASSENGER TANK LOCOMOTIVE; SUNG-WU RY., CHINA.
Built by The Brooks Locomotive Works, Dunkirk, N. Y.

Tank Locomotive; Sung-Wu Railway, China.

Running Gear:	
Driving wheels, diameter	(1,500 mm.) 59 in.
Truck wheels, diameter	23 "
Journals, driving axles	7½ × 9 "
" truck axles	6½ × 10½"
Wheel Base:	
Driving	7 ft. 6 "
Total engine	20 " 0 "
Center of leading truck to c. leading driv. axle	6 " 3 "
Trailing truck to c. trailing driving axle	6 " 3 "
Weight in Working Order:	
On driving wheels	50,000 lbs.
On leading truck	29,000 "
On trailing truck	24,800 "
On trucks	53,800 "
Engine, total	112,800 "
Of full coal capacity	4,000 "
Of full water capacity of tank	11,000 "
Cylinders	(420 × 600 mm.) 16.53 × 23.62 ins.
Distance, center to center	6 ft. 2 "
" center to valve face	1 " 1¾"
Piston rod, diameter	3 "
Crosshead and guides	Laird type.
Connecting rod, length between centers	6 ft. 2 ins.

Valve Gear:	
Type	Shifting link.
Ports, steam	1⅜ × 15 ins.
Ports, exhaust	2½ × 15 "
Slide valves, lap	⅞-in.
" lead	1-16-in.
" maximum travel	5 ins.
Boiler:	
Type	Wagon top.
Diameter of barrel inside	3 ft. 11¼ ins.
Thickness of barrel plates	7-16 and ½-in.
Thickness of smokebox tube plate	½-in.
Height from rail to center line	7 ft. 3 ins.
Length of smokebox	3 " 9 "
Working steam pressure	176.4 lbs.
Firebox:	
Type	Sloping; crown bar.
Length inside	6 ft. 6 ins.
Width inside	2 " 10 "
Depth at front	5 " 3½"
Depth at back	3 " 10½"
Thickness of side plates (annealed copper)	½-in
" back plate " "	½-in.
" crown sheet " "	½-in.
" tube sheet " "	¾-in.
Grate area	17.9 sq. ft.
Stayboits diameter..1-in.; pitch..4 ins.	
Water space ...width, back and sides, 3 ins.; front, 4 "	
Tubes.—Charcoal iron; number	165
Pitch	2⅝ ins.
Diameter, outside	2 ins.
Length over tube plates	11 ft. 1 5-16 ins.
Heating Surface:	
Ratio to grate area	58.7 to 1
Ratio exterior tube area to firebox heating surf.	53.46 to 1
Tubes, exterior	957.0 sq. ft.
Firebox	93.8 "
Total with exterior tube area	1,050.8 "
Miscellaneous:	
Exhaust nozzle, diameter	4, 4¼, 4½ ins.
Smokestack, smallest diameter	1 ft. 2¼"
Smokestack, height from rail to top	13 " 4½ "
Capacity of tank	1,320 gallons
Capacity of coal space	3,527 lbs.
Total adhesive tractive power, at ¼ of weight on drivers	28,200 "

GERMAN ARTIFICIAL FLOORING.

In the "Consular Reports" for August, 1867, Mr. J. C. Monaghan, U. S. Consul at Chemnitz, Germany, reports upon several forms of artificial flooring lately introduced into Germany. The Knoch cork stone flooring is highly commended for its insolating properties. It is made of ground cork, ground tan-bark, ground peanut shells or other suitable material of that class, and is mixed with paper waste, alum, or other fireproof materials and molded into bricks. These bricks are dried in kilns before use, and the product is damp and sound proof, and, to a large extent, fireproof. These bricks may char, but will not blaze.

The same Knoch has invented an elastic material which is absolutely fire, water, moisture and acid proof, and will not crack when used for flooring, walls, etc. It is made by dissolving chloride of magnesium in water at 27° Beaume. One pound of salt is then thoroughly dissolved in about one quart of cold water. To this is added 66 lbs. of burnt powdered magnesium and 4.4 lbs. of finely ground leather waste, and the compound is mixed by hand in a tub. Of this mixture, 13.2 lbs. are mixed with 5 liters, or 5.28 quarts of the chloride of magnesium solution, and the resultant mass is thoroughly kneaded by hand or in a machine until a uniform pulpy mass results.

This mass is then spread over the surface to be covered, and kept from running by wooden or sheet iron forms. It is smoothed by a tool, and a beautiful surface is formed. The addition of more of the leather meal, or 6.6 lbs. instead of 4.4 lbs., makes it a still better non-conductor. To further insulate and to provide an elastic floor, a layer of dry cork meal is placed between two layers of the above mixture. This covering can be used over stone, brick or old floors, and can be walked upon 12 hours after laying. It has a surface as hard as stone, but is as elastic as wood. Any pattern may be impressed upon it by forms, and the material may be produced in sheets ready for shipment to any point.

The cost is small; 100 kilos., or 220 lbs. of the mixture, costs $1.66. For surface work, a square metre, 10 mm. thick, costs 83⅓ cts.; 15 mm. thick, it costs $1.19, and for 30 mm. thick, it costs $2.38 per sq. metre.

A HEAVY-WEIGHT MOTOR-CARRIAGE TRIAL IN FRANCE.

The Automobile Club, of France, lately organized a six-days' test of motor carriages of a heavy class, or motors fitted for carrying a minimum useful load of 1,000 kilos., or 2,200 lbs., either in passengers or merchandise. Each motor was required to twice traverse each one of three different routes radiating from Versailles and ranging from 24 to 40 miles in length. A close account was to be kept of the total expense of operation, with the different elements entering into this cost carefully separated. Three classes were made: 1. Vehicles which were able to carry, operators not included, at least 10 passengers with 30 kilos. of baggage; 2. Vehicles fitted to carry at least one ton of merchandise; and 3. Mixed vehicles, for carrying at one time both passengers and merchandise, with a maximum load of one ton. Each motor had to run at least 9.3 miles without recharging; and on the 40-kilometre course, stops were to be made at each kilometre; on the 50-kilometre course, at every 50 kilometres, and on the 65-kilometre course, at every 10 kilometres. Stops had also to be made on up and on down grades, and upon macadam and paved streets.

According to "Le Genie Civil' 10 motors presented themselves for trial on Aug. 5, though 15 had originally entered for the trial. These are described as follows:

No.	Builder.	Type.	Motor.	HP.	No. Pass.	Loads of freight.
1.	Scotte	Passenger	Steam,	16	32	2,112 lbs.
2.	"	Freight	"	16	..	12* tons
3.	"	Mixed	"	16	12	660 lbs.
4.	Weidnecht	Omnibus	"	34	30	...
6.	Le Blaut	Brake	"	12	10	1,100 lbs.
8.	De Dietrich	Truck	Petro.	6½	..	2,640 "
10.	Panhard	Omnibus	"	12	10	660 "
13.	De Dion & Bouton.	Traction eng.	Steam,	25	..	5 tons
14.	" "	Omnibus	"	25	16	1,056 lbs.
15.	Maison Parisienne.	Brake	Petro.,	9	12	792 "

* 10 to 12 tons.

No. 7, a Le Blaut brake, did well the first day; but the roof having caught fire in the afternoon, it was abandoned; No. 4 was left out of the race in the third day owing to an accident to its frame, and No. 15 had to throw out some of its load to enable it to ascend the grades. The other seven motors went regularly over the course; with some slight accidents, but in good condition, and with a very satisfactory average result. The Scotte motors fulfilled all the conditions imposed with great regularity, and motors 13 and 14 were in every way successful. While the greatest success thus seemed to belong to the steam motors, the petroleu n motors behaved well. The Panhard motor was beautifully modeled and was furnished with two petroleum motors coupled, of 6-HP. each; it made the trip in excellent condition and at a good speed. No. 8 motor, with a 6½-HP. petroleum engine, also fulfilled all conditions of the test.

The purpose of the trial was to furnish truly practical and industrial results, and the behavior of the motors was closely watched by the military engineers. The official report of the commission has yet to be published, but the general result was satisfactory, and it is believed that similar motors could be successfully applied to industrial transportation.

PAINT TESTS.*

By Max Toltz,† Member Civil Engineers' Society of St. Paul.

This paper records the result of considerable thought, study and time, which have been given to the above subject during the last three years in making careful laboratory examinations of the various paints sold in the markets as "anti-rust," and under other names, and in practical experiments.

The compilation of the work thus far done is given in a condensed form only; therefore, the usual style of reporting is reversed, and the recommendations and conclusions arrived at are given at the beginning. From our present knowledge, the following system for painting iron and steel bridges and other metallic structures is recommended:

1. Give the iron and steel a coat of the best grade of refined linseed oil, properly boiled and settled clear; or, still better, mix linseed oil with about 10% of a good grade of lampblack; this coat to be applied at the mills, the iron or steel being first carefully cleaned from loose scales.

2. After the structures have been erected, give them one coat of real asphaltic varnish paint, made from the best grade of asphalt, linseed oil and gum, compounded properly, so as to form a true varnish; or of a paint made from carbon black and a properly boiled varnish, compounded of the best grade of linseed oil and gum. This coat should be carefully applied by a skillful painter, after the metal has been thoroughly cleaned from all loose scale, rust, shavings, filings, shrivelled oil or paint, grease, dirt, or any foreign matter, because it is of the utmost importance that the paint should be spread and worked in such a way so as to cover the surface properly, and be as free as possible from air bubbles and form a continuous coating. This priming or first coat should be applied fairly thick, the thickness depending, to some extent, on the nature of the paint used. Before the second coat is applied, the first one should be thoroughly dried and hardened by natural oxidation, which will require at least ten days. If practicable, it would be a great deal better, as well as more economical, to apply the second coat not less than four weeks after the first one.

3. As a second coat, a good grade of graphite paint is to be applied as thickly as possible, working the paint thoroughly with the brush. From the examinations made of the various grades of graphite paints, as far as graphitic pigments are concerned, there appears to be but little difference between them, provided, of course, that the pigment contains at least 33% of pure graphite, the rest of the pigment being natural rock, ground very fine in pure linseed oil. The graphite paint should be bought in paste form, well ground, and contain not less than 70% of pigment and 30%, by weight, of the best quality of boiled linseed oil; the paste should be mixed with boiled linseed oil at the place where it is to be applied. No turpentine, no benzine, and no Japan or driers should, under any circumstances, be allowed in this paint.

The system just described, if properly carried out, will give a protective coating which will last for many years, and it is firmly believed that this system of painting (provided that the paints are of the best quality) will protect iron and steel for a longer period than any other system now in vogue.

4. There are certain parts of steel or iron bridges, viaducts or tunnels that should have an additional (third) coat of paint. These include such places, or parts of structures, as are directly exposed to the steam, fumes and gases from passing engines. For such a coat some cheaper asphalt paints, applied very thickly over the coats above recommended, would be all-sufficient. Such a coat would protect the underlying primary coats for many years, preserving their natural toughness and elasticity, and preventing atmospheric action on the structure.

In the past, red lead was largely, if not exclusively, used as a paint for iron and steel structures, but within the last ten years it has been to a great extent discarded by progressive engineers and builders. It is true that we to-day have advocates of red lead as the best paint. Still, the fact that these so-called red-lead men now begin to add carbon black or graphite to their paint, is a sure sign that they themselves no longer believe red lead to be the best pigment.

Fifteen years or more ago iron-oxide men appeared and flooded the country with their various grades and qualities of iron-oxide paint, as being the paint which nature itself had provided for the protection of steel and iron structures against rust and corrosion. From the investigations made, as well as from practical experiments, it appears that the iron-oxide paints are not very desirable, at least for the first coat or two, for iron or steel; but, as a third coat, for the protection of the underlying paints, they may be recommended.

However, the extensive investigation of the graphite paints that can be obtained in the markets to-day shows that, if properly applied, they are far superior to iron-oxide paints for the second or third coat, especially as they withstand the action of moisture and water much better than the best iron-oxide paint so far examined. Besides, a graphite paint, in paste form, well ground and mixed with boiled linseed oil, will not cost very much more per gallon than the cheapest iron-oxide paint in the market.

In recommending asphalt varnish paint or carbon paint for the first coat, great stress is laid upon the necessity of having the surfaces of iron or steel as free from moisture as possible while the structures are being painted, otherwise there is great danger that the coating will not adhere very firmly, and that it will thus actually nullify the value of the paint. This precaution is less important when an ordinary iron-oxide paint or red-lead paint, simply mixed with linseed oil, is used; because linseed oil itself has the property of absorbing moisture quite readily, whereas carbon or asphalt paint will not. The lack of this property in the two last-named paints is one of the principal reasons why they are superior to any other class of paints.

Although it is proper that true economy should always be exercised, preference should not be given to any paints whose properties lie simply in the fact that small quantities of them cover great areas. Often the first question asked is: "How many square feet can you cover with a gallon of your paint?" cheapness being considered the most important factor. Of course, the greater the number of feet that can be covered with one gallon of paint the thinner will be the protecting coat. There is a limit beyond which it is inadvisable to carry this. Other things being equal, the paint that can be spread over a fairly good area should be considered superior to any which goes to the extreme either way.

†Bridge Engineer, Great Northern Ry.

*Slightly abbreviated from a paper read before the Civil Engineers' Society of St. Paul and published in the "Journal of the Association of Engineering Societies."

The various paints examined are classified under the following heads:

1. True asphaltic varnish paints.
2. So-called asphaltic varnishes or paints, of inferior qualities.
3. Black carbon paints, in which the vehicle is practically a varnish.
4. Iron-oxide paints, consisting of more or less iron-oxide with more or less siliceous matter and compounds of lime or of magnesia.
5. Graphite paints and silica graphite paints.

The tests were carried on through periods ranging from six months to over two years. The number of paints subjected to test was twenty-two. All these paints have been analyzed chemically to ascertain the quality of material used in them.

The true asphaltic varnish paints are compounded in the same manner as the black japans, known as baking japans, and are made practically in the same way as varnishes, from linseed oil, gum, asphaltum and turpentine. Some of them contain carbon black and a small amount of inert mineral matter.

The carbon paints consist, as regards the pigment, mostly of carbon black, with some white lead; the vehicle in which the paint is ground is practically a linseed oil varnish, thinned down with turpentine. These two paints are closely related to one another and are comparable. Both are considered to be of great value for the protection of iron and steel, if properly applied.

The asphalt paints of inferior quality, which might be of value as a last coat, or wearing coat, especially on certain parts of bridges, viaducts or tunnels, are made of asphaltum dissolved in benzine or other volatile oils, but are not a true varnish made from linseed oil. They contain about 43% of volatile oils and 56.5% of solid carbonaceous bitumen (asphaltum).

In using these paints, namely, asphalt dissolved in benzine, in mixtures of benzine or rosin spirit, or in other light neutral oils, the principal trouble is that in spreading them over oiled surfaces the light oil evaporates so fast that it is difficult to spread them properly. There is also another objectionable feature in connection with the benzine paint, namely, that where such a paint is applied to iron surfaces the rapid evaporation of the benzine absorbs a great deal of heat, and, if the air should happen to be highly saturated with moisture at the time, the reduction in the temperature of the surface of the adjacent iron may cause a condensation of moisture, preventing the paint from coming in close contact with the iron and producing a tendency to blister.

These cheap asphaltic paints may show up well enough in the beginning, but as a rule, after the volatile oil has evaporated, especially in subjecting the painted iron to the heat test, the coats become quite brittle, can be easily removed by abrasion and do not protect the iron against rust.

As a matter of interest, it may be here stated that one of the so-called asphaltic paints when analyzed chemically showed no asphaltum at all.

The iron-oxide paints were of different grades and qualities. It is not the intention of the writer to give their chemical analysis, because every paint was compounded differently and contained more or less iron oxide and siliceous matter. As a rule the paints were well ground, and spread and covered to a satisfactory extent.

As stated before, the graphite paints contain from 33 to 83% graphite, the balance being inert insoluble matter, consisting mostly of compounds of lime, magnesia, alumina and iron-oxide.

Besides the chemical examination, the paints were subjected to a systematic practical test, to ascertain their real values as anti-rust paints. For that purpose comparative tests, by painting pieces of sheet iron, tinned iron and galvanized iron, wooden boards and shallow sheet iron dishes, were carried on. The iron dishes were about 12 ins. in diameter and about ½-in. deep, having a capacity of about ½ pint. The scale or skin was carefully removed before painting, so as to have a clean surface of iron exposed next to the paint. Two dishes were painted with each kind of paint—one of them receiving one coat, the other two coats, the first coat having dried thoroughly (for at least a week) before the second coat was applied. After the second coat had completely dried and hardened, these dishes were exposed to the so-called water-and-moisture test, in which a given amount of water is placed in the dishes and allowed to evaporate to dryness at the ordinary temperature of the room. This is repeated a number of times, until the inside of the dishes begins to show more or less rust. All dishes were carefully examined before each refilling. After most of the water has evaporated, there remains, at the junction around the edge, a thin film of water, which, in contact with the air and with the carbonic and other acids in the air, acts on the paint in such a way that the iron under the paint begins to rust. The rust thus formed develops more and more after each evaporation, in some cases practically covering the whole dish in a short period. In actual practice and service, the same thing will happen, the only difference being that the rust will extend under the paint and will not show as plainly as on the dish. This test is a most important and severe one for the purpose of determining in a relatively short time the weather-resisting power of a paint. If the paint is unable to resist this action of the water or moisture under these conditions, it cannot be desirable for the protection of iron or steel structures. But other qualities in the paint have to be taken into consideration in connection with this test before a correct opinion as to its merits can be formed.

The dishes painted with true asphalt varnish and with the carbon were refilled fourteen times. The dishes painted with one coat showed very little deterioration, while the dishes with two coats showed none at all, the paint being as elastic and tough as when first applied.

The behavior of the cheap and inferior so-called asphalt paints, applied on the surfaces of the dishes, was quite different. After the fifth exposure, the dishes with one coat showed considerable rust all over. Those with two coats, after the seventh exposure, showed not much better.

Quite a difference was apparent in the test of the iron-oxide paints. On the average, after the fifth exposure, a good many rust spots or specks appeared on the surfaces of the dishes painted with one coat. The dishes with two coats were refilled six times and on them rust could be easily detected with the naked eye.

The graphite paints so far examined acted much the same in comparison with one another; although, upon chemical examination of the samples submitted, quite a variation was found in the amount of graphite present in the pigment.

The object of procuring the graphite in the form of paste was, in the first place, to get the paints ground only in boiled oil, so that they could be thinned with oil before painting, under exactly the same conditions; second, if, after the examinations and tests, any difference was found, it would be easy to ascertain whether or not such difference was due to the amount of graphite present. In mixing these different graphite paints with boiled linseed oil, ready to apply 4½ parts of paint and 3½ parts of oil, by weight, were used. As all these graphite paints were received at about the same time, all the comparative tests were made under exactly the same conditions, and all moisture or water tests were made side by side. Therefore, the results obtained so far are comparative and consequently of more value than otherwise would have been the case. All the dishes with one coat were exposed ten times to the water test, and on examining the records it will be observed that all these graphite paints began to show a few specks of rust after the fifth evaporation, and that the number gradually increased after each successive evaporation. After the tenth exposure some slight difference between them is shown, but not very much. All the dishes given two coats have so far been exposed thirteen times, and none of them show any rust or indication of rust. The natural toughness and elasticity is still in the paint after the treatment.

Besides this moisture-and-water test, all paints have been subjected to a heat test, by placing painted sheet iron in the core oven of the brass foundry of the Great Northern Railway shops. The temperature of this oven varies from 220° to 300° Fahrenheit, and, as the fire is a direct one, all the gases of combustion, such as carbonic acid, sulphurous acid, and watery vapor, came in direct contact with the painted iron. This test is of value also as showing promptly whether a paint will keep its elasticity or will become brittle so that it may be easily removed from the surface. In several instances this test brought out serious defects in some of the paints examined, which had shown fairly good results in the other tests. This was the case especially with the cheaper so-called asphalt paints.

After a month's exposure to the heat of this core oven, the painted pieces of sheet iron were examined, and the asphaltic varnishes, carbon paints and graphite paints only were then found in good condition, although the paint had become very hard, owing to the thorough oxidation and hardening of the linseed oil. These three paints adhere very firmly to the iron after the heat treatment; in fact they seem to be more strongly attached to it than to a painted surface not exposed to heat.

The exposure of the painted iron to this high temperature is not exactly the same condition to which it will be subjected in actual service; but this test, in connection with the others, is of value, because if the paint should become very brittle or should flake off and be easily removed from the painted surface during this test, it will surely do so in practice after a long exposure to the direct action of the sun, and to great variations in temperature.

The writer wishes to give due credit to Dr. P. H. Conradson, who very skillfully carried out these tests when at the head of the Great Northern Laboratory.

AMERICAN TUNGSTEN.

The discovery of extensive deposits of tungsten in an extinct volcanic formation near Bridgeport, Conn., should have considerable effect upon the more extended use of this somewhat rare mineral in the arts in the United States. These Trumbull Mines, as they are called, are now being worked commercially by the Rare Minerals Mining Co., of New York, and the tungsten can be obtained in a quantity and at a price previously unknown to metal workers.

Tungsten is harder than any other commercial metal, and has a specific gravity of 19, or almost that of gold. Its chief use at the present time is by the steel makers, as it is claimed that steel can be hardened indefinitely by the addition of tungsten; though too large a percentage of tungsten causes the steel to be brittle from excessive hardness. The supply of tungsten has heretofore been very limited. It is found in certain tin mines in Cornwall, England, in the form of wolframite; in Bohemia, in Saxony and in Spain, and in small quantities in several of the Australian Colonies. The owners of the Trumbull Mines, in Connecticut, claim that they can produce 1,000 tons per year.

Tungsten is now used to a considerable extent by makers of the finest tool steel; Krupp uses it largely for this purpose, and the French manufacturers especially recommend it. Among the uses which would follow a larger available supply of this alloy are mentioned the manufacture of projectiles and armor-plate and spring steel, its employment in X-ray photographs and for electric lighting purposes, and in the arts generally as a hardening alloy for other metals. In electrical work the tungstate of calcium, or scheelite has been successfully experimented with as a coating for the inside of electric-light bulbs, doing away with the filament entirely. This is the fluorescent lamp, for which the claim is made that about 75% of the energy is transformed into light, with the development of only 25% in heat. This metal is said to add valuable qualities to piano sounding-plates; it is especially useful in bronze-making, giving great resistance to abrasion, and, in the form of tungstic acid, it has been used in rendering clothing incombustible, and in fireproof construction. As tungstate of soda it is now employed in the manufacture of a substitute for rubber. In fact, the uses of this rare metal are already numerous and important, and if the American deposits are put upon the market in the quantities expected, these uses will doubtless multiply rapidly.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Basis of Estimate for Public Improvements.

The preliminary estimate by the city engineer for the cost of a proposed street improvement should be based upon the cost for cash; but the subsequent proceedings will not be held void merely because such estimate was based on payment in city bonds at ninety cents on the dollar; the cost for cash being readily ascertainable from the estimate made, and the contract price being less than such ascertainable cash estimate. Kans. Town Co. v. Argentine (App. Ct. Kans.), 47 Pac. Rep., 542.

Liability for Temporary Bridge.

A contractor for the erection of a public bridge, who agrees to erect a temporary bridge pending the construction of the permanent one, and to keep it in good repair during the progress of the work to be done under the direction of the engineer, is liable for injuries caused by failure to keep it in such repair, though he had not been notified by the engineer that repairs were needed. Cook v. Dean, 42 N. Y. Supp. Rep., 1040.

Contractor's Bond Not Released.

The sureties on a contractor's bond to indemnify a city against actions for personal injuries caused by the negligence of such contractor are not discharged by the city paying him the entire consideration of the contract, though it knew that an action was pending against it within the bond, where such sureties also knew of the action and its nature, but served no written notice on the city, as they might have done under the contract, to withhold the money due to the contractor. New York City v. Brady, 45 N. E. Rep., 1,122.

Damages for Breach of Contract.

The measure of damages for breach of a contract to take crushed rock at a specified price is the difference between the contract price and what it would have cost the seller to furnish the material. Am. Bridge & C. Co. v. Bullen Bridge Co., 46 Pac. Rep., 138.

Right to Depart from Chartered Right of Way.

Street railway companies, though not clothed with the power of eminent domain, may buy a right of way required for their use, and may diverge from their chartered right of way for a short distance when necessary to avoid discomfort or danger to the traveling public, because of the conformation of the surface or the positions of streams, etc. Del. & H. Canal Co. v. L. V. Trac. Co., 2 Lack. L. News, 205.

When City May Incur Debt in Excess of Limit.

A town which has reached the limit of indebtedness may contract a further liability if it has or will have in its treasury a fund specially set apart for liabilities of the kind. McAleer v. Angell (R. I.), 36 Atl. Rep., 588.

Proper Elements of Damage to Contractor.

The loss sustained by a sewer contractor from being obliged to surrender a contract for the purchase of brick, owing to the unlawful suspension of the work by the city and the subsequent purchase of brick at an increased price, and the increase in wages which he was compelled to pay, owing to the same cause, are the proximate result of such suspension and proper elements of his damage. King v. Des Moines (Supp. Ct. Ia.), 68 N. W. Rep., 708.